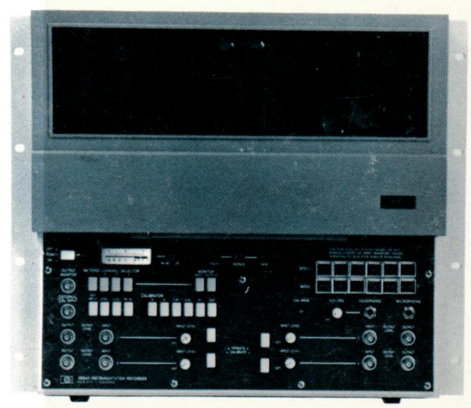
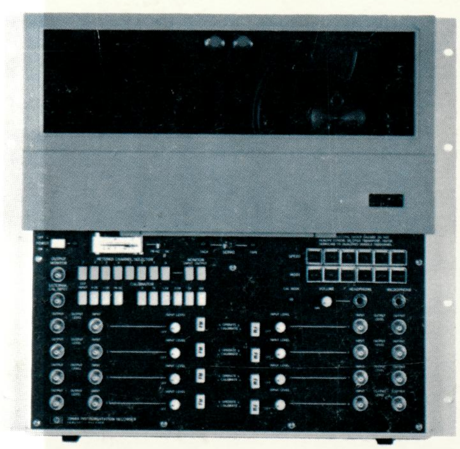
OPERATING AND SERVICE MANUAL

INSTRUMENTATION TAPE RECORDERS

3964A/3968A





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SAFETY

This product has been designed and tested according to International Safety Requirements. To ensure safe operation and to keep the product safe, the information, cautions, and warnings in this manual must be heeded. Refer to Section I for general safety considerations applicable to this product.

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard product is warranted against defects in materials and workmanship for a period of 1 year from date of shipment. During the warranty period, HP will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. However, warranty service for products installed by HP and certain other products designated by HP will be performed at Buyer's facility at no charge within the HP service travel area. Outside HP service travel areas, warranty service will be performed at Buyer's facility only upon HP's prior agreement and Buyer shall pay HP's round trip travel expenses.

For products returned to HP for warranty service, Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OR MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

OPERATING AND SERVICE MANUAL

INSTRUMENTATION TAPE RECORDERS
3964A/3968A

SERIAL PREFIX: 1821A

03964-90007
03964-90057 (Microfiche)

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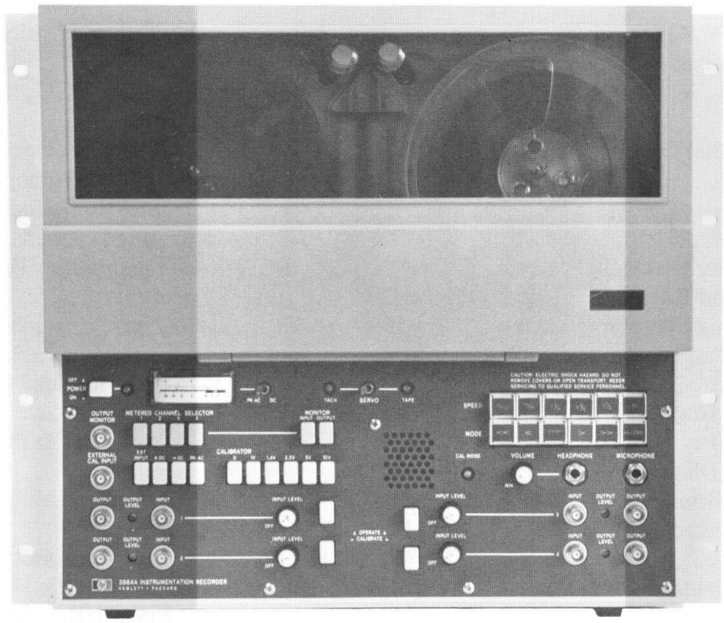
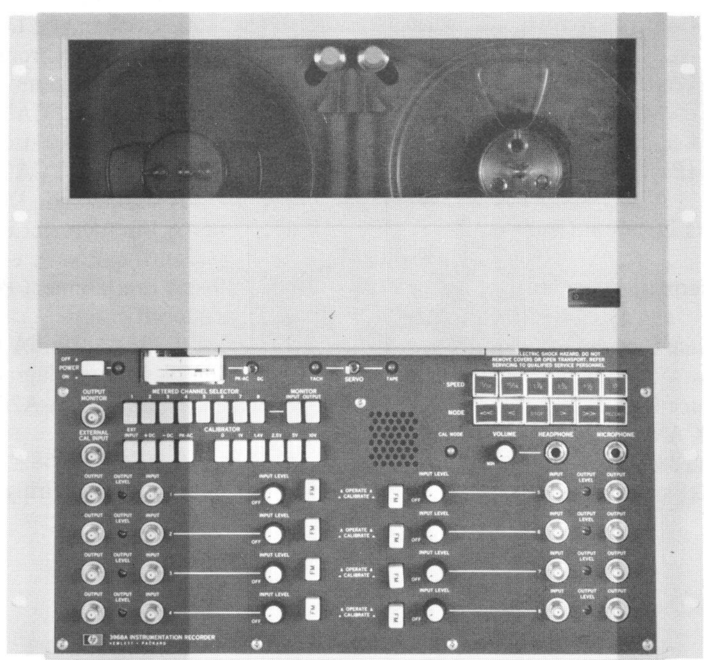


3964A



3968A

Figure 1-1. Model 3964A and 3968A Instrumentation Tape Recorders

SECTION I

GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This manual contains operating and service instructions for the Hewlett-Packard Models 3964A and 3968A Instrumentation Tape Recorders. The Model 3964A is essentially the same as the Model 3968A except that the unit has four recording and playback channels rather than eight. All information in this manual applies to both instruments, except where noted, and illustrations show the Model 3968 only rather than duplicating each illustration. The manual is arranged in seven sections as follows: General Information, Installation, Operating Instructions, Theory of Operation, Maintenance, Parts List, and Circuit Diagrams.

1-3. DESCRIPTION.

1-4. The Model 3968A is an eight-channel, six-speed instrumentation recorder while the 3964A has four channels. Both instrumentation are shown in Figure 1-1. Each recorder uses 1/4-inch magnetic tape, and is capable of FM recording over a bandwidth of dc to 5 kHz and/or direct recording of signals of up to 64 kHz. All tape motion and speed controls, plus status of operating controls, speed controls, servo lock, and end of tape (EOT) condition states are available on a rear system connector. Controls are activated by either contact closure to ground or transistor-transistor logic (TTL). Status lines are TTL compatible. The instrument will operate in a vertical or a horizontal position and can be mounted in a standard 19-inch equipment rack (Option 026) or in an HP cabinet (Option 027). Rack mounting brackets are standard. Power requirements for the recorders are 100, 120, 220, or 240 Vac +5 -10% at any frequency between 48 and 440 Hz.

1-5. MAGNETIC TAPES.

1-6. Type 3M888 Magnetic Tape (HP Part No. 9162-0066), or equivalent instrumentation tape, is recommended for use with the Recorders. Provisions are included on the data PCA's to equalize for other tapes; however, the specifications published herein are valid only when using Type 3M888 or equivalent. Refer to Section V for equalization procedures.

1-7. IDENTIFICATION.

1-8. This instrument has a two-part serial number. The first four digits and the letter comprise the serial number prefix. The last five digits form the sequential suffix that is unique to each instrument. The contents of this manual apply directly to instruments having the same serial number prefix(es) as listed under SERIAL NUMBERS on the title page. An instrument manufactured after the printing of this manual may have a serial prefix that is not listed on the title page. This unlisted serial prefix indicates that the instrument is different from those documented on this manual. The manual for this instrument is supplied with a yellow Manual Change Supplement that contains "change information" that documents the differences. In addition to change information, the supplement may contain information for correcting errors in the manual. For information concerning a serial number prefix not listed on the title page or in the Manual Change Supplement, contact your nearest Hewlett-Packard Sales/Service Office. The addresses are tabulated on the last two pages of this manual.

1-9. SPECIFICATIONS.

1-10. Specifications for the recorder are listed in Table 1-1.

1-11. OPTIONS.

1-12. Options that can be used with the Models 3964A and 3968A are listed in the following paragraphs. These options that can be field installed are listed in Table 1-2 with kit and instruction part numbers.

1-13. OPTION 001, FM RECORD/REPRODUCE PCA.

1-14. Option 001 enables the operator to record and reproduce signals over a range from dc to 5 kHz, (see Table 1-1 and Figure 1-2). The PCA can be installed in any of four channels in the 3964A and eight channels in the 3968A. These units can be intermixed with Direct Record/Reproduce PCA's. The user orders as many PCA's as required.

1-15. OPTION 002, DIRECT RECORD/ REPRODUCE PCA.

1-16. Option 002 is used to record and reproduce direct signals in a range between 100 Hz and 64 kHz (see Table 1-1 and Figure 1-3). The user orders as many Direct PCA's as required.

1-17. OPTION 003, REAR PANEL DATA CONNECTORS.

1-18. Option 003 provides BNC connectors mounted on the back cover of the instrument for signal input and output (16 connectors on the 3968 and 8 connectors on the 3964) (see Figure 1-4).

1-19. OPTION 004, LOCKING KNOBS.

1-20. Option 004 provides locking knobs to prevent accidental misadjustment of input level controls. Locking the knob secures the desired control (see Figure 1-5).

1-21. OPTION 005, METRIC TAPE SPEEDS.

1-22. Option 005 provides speed control pushbutton inserts with the metric equivalent of the standard tape speeds. The metric speeds are as follows:

15 ips = 38.10 cm/sec
7-1/2 ips = 19.05 cm/sec
3-3/4 ips = 9.52 cm/sec
1-7/8 ips = 4.75 cm/sec
15/16 ips = 2.38 cm/sec
15/32 ips = 1.19 cm/sec

1-23. OPTION 007, HP-IB INTERFACE.

1-24. The HP-IB electronics (see Figure 1-6) are used to permit mode selection and tape speed control of the recorder by a remote controller using the standard instrumentation interface techniques defined in IEEE Standard 488-1975. The interface electronics are contained on four PCA's, which are connected to the recorder electronics by cable.

1-25. OPTION 009, UL-544 LISTED, WHITE PAINT.

1-26. Listed by Underwriters Laboratories, Inc. External parts of the tape recorder are painted white to match a medical facility environment. Equipped with rear input/output connectors only. Not compatible with Options 001, 002, 003 and 021. Uses an Option 030 FM Record/Reproduce PCA or an Option 031 Direct Record/Reproduce PCA. Operating instructions are contained in an Operating Manual (HP Part No. 03964-90009) and service instructions are contained in a Manual Supplement (HP P/N 03964-90010) dated December 19, 1977.

1-27. OPTION 010. UL-544 LISTED, STANDARD PAINT.

1-28. This option is the same as Option 009, except the instrument is painted with the same colors as is the standard instrument. The instructions for an Option 010 instrument are contained in the two documents referenced in paragraph 1-26.

1-29. OPTION 021, DC POWER OPERATION.

1-30. This recorder can be operated from 12 Vdc or 28 Vdc power source, or a 115 Vac or 220 Vac line voltage. A separate supplementary document (Part No. 03964-90006) is provided with this option (see Figure 1-8).

1-31. OPTION 024, TAPE LOOP ADAPTER.

1-32. The tape loop adapter provides the capability of recording 5 to 30 foot tape loop (see Figure 1-9) for continuous playback. The option is used to simplify data analysis by providing continual replay of the tape.

1-33. OPTION 026, RACK SLIDES FOR 19-INCH RACK.

1-34. Option 026 provides extension slides that can be mounted on the unit so that the recorder can slide from the rack and be rotated to a 90° angle for accessibility (see Figure 1-10).

1-35. OPTION 027, RACK SLIDES FOR AN HP CABINET.

1-36. Option 027 provides for mounting the recorder in a Hewlett-Packard cabinet. The rack slides are similar in appearance to those used for the 19-inch cabinets (see Figure 1-10).

1-37. OPTION 041, INTER-RANGE INSTRUMENTATION GROUP (IRIG) SERVO REFERENCE FREQUENCY.

1-38. Option 041 provides IRIG (Inter-Range Instrumentation Group) servo reference frequency. Includes replacement of standard servo reference crystal (108 kHz) with an Option 041 crystal (100 kHz), and changing the capstan assembly. Used with the recorder is operated with IRIG compatible reference frequencies during recording or reproducing.

1-39. OPTION 070, OVERLAP.

1-40. Overlap operation allows one tape recorder to take over the recording of signals being recorded by another unit just before the first recorder runs out of tape. The recording process is thus continued with a recording overlap between the two machines (see Figure 1-11). Any number of instruments can be connected together for overlap operation.

1-41. POWER CORD OPTIONS.

1-42. Several power cords are available. Refer to paragraph 2-26 and Figure 2-8 for a description.

1-43. ACCESSORIES SUPPLIED.

1-44. Accessories supplied with the Model 3964A/3968A are listed in Table 1-3, and are shown in Figure 1-12.

Table 1-1. Specifications

TAPE TRANSPORT

NUMBER OF CHANNELS

Four (3964A); Eight (3968A)

TAPE WIDTH

1/4 inch

REEL SIZE

Standard 7-inch plastic reel; totally enclosed by reel cover.

TAPE SPEEDS

15, 7-1/2, 3-3/4, 1-7/8, 15/16, and 15/32 ips. Electrically selected by front panel illuminated pushbuttons.

TAPE SPEED ACCURACY

±0.2%

FLUTTER

Tape Speed	Passband (Hz)	Flutter (% p-p)
15	0.2 – 2500	.35
7-1/2	0.2 – 1250	.35
3-3/4	0.2 – 625	.40
1-7/8	0.2 – 312	.50
15/16	0.2 – 156	.70
15/32	0.2 – 78	1.50

REFERENCE OSCILLATOR ACCURACY

±0.02%

CAPSTAN DRIVE

DC motor with phaselock servo.

START AND STOP TIMES (TYPICAL)

TAPE SPEED (ips)	START (seconds)	STOP (seconds)
15	3	0.30
7-1/2	1.50	0.30
3-3/4	0.90	0.30
1-7/8	0.50	0.30
15/16	0.50	0.30
15/32	0.50	0.30

REWIND TIME (TYPICAL)

1800 foot reel in 100 seconds, 2300 foot reel in 145 seconds.

END OF TAPE SENSING (EOT)

Tape drive stops if tension between capstan and both reels is lost.

REEL REVOLUTION COUNTER

Four-digit revolution counter with pushbutton reset.

TAPE MOTION CONTROLS (OPERATING MODES)

Forward and reverse record, forward and reverse play, fast forward, fast reverse and stop; all pushbutton selectable.

REMOTE CONTROL AND STATUS

All tape motion and speed controls, plus status of operating controls, speed controls, servo lock, and EOT, are available on rear system connector. Controls activated by either contact closure to ground or TTL Logic Levels. Status lines are TTL compatible.

TIME BASE ERROR

TAPE SPEED (ips)	TIME BASE ERROR (μs)
15	± 4.0
7-1/2	± 5.0
3-3/4	± 7.5
1-7/8	±15.0
15/16	±25.0
15/32	±50.0

HEADS

3964A: One four-track record head, and one four-track reproduce head using in-line track configuration.

3968A: One eight-track record head, and one eight-track reproduce head interlaced odd-even track configuration.

Table 1-1. Specifications (Continued)

FM RECORD/REPRODUCE SPECIFICATIONS (USING 3M-888 TAPE) OR EQUIVALENT

PASSBAND AND SIGNAL-TO-NOISE RATIO

TAPE SPEED	CARRIER CENTER FREQ (kHz)	PASSBAND (1) (Hz)	S/N RATIO (2) dB (3)	
			3964A	3968A
15	27.00	DC – 5000	48	46
7-1/2	13.50	DC – 2500	48	46
3-3/4	6.75	DC – 1250	48	46
1-7/8	3.38	DC – 625	46	46
15/16	1.69	DC – 312	44	44
15/32	.85	DC – 156	40	40

1. Frequency response over passband is ±1.0 dB referenced to 10% of upper bandedge frequency with Amplitude/Phase selector in Amplitude position.
2. Signal measured with carrier deviation ±40% at 10% of upper passband.
3. Without flutter compensation. Output filters of reproduce amplifiers selected for constant amplitude response. May also be selected for linear phase (transient) response.

FLUTTER COMPENSATION

Can improve signal-to-noise by up to 4 dB under static conditions and as much as 12 dB under conditions of vibration. (Selected by rear panel switch).

DISTORTION

Total harmonic distortion <1.25% @ 15 to 1-7/8 ips, <2% @ 15/16 – 15/32 ips.

LINEARITY

±0.3% of p-p output for best straight line through zero at ±40% deviation.

DC DRIFT

±0.1% (max) of full scale output per °C.

INPUT LEVEL

1V to 30V (p-p); continuously adjustable.

INPUT IMPEDANCE

100 KΩ nominal, shunted by <100 pF single ended.

OUTPUT LEVEL

1 to 5V (p-p); continuously adjustable.

OUTPUT IMPEDANCE

50 ohms nominal, single-ended (minimum load impedance 600 ohms).

NON-BIAS RECORDING

Available by internal jumper selection; all FM system only.

"E-TO-E" MODE

Electronics-to-Electronics mode enables input signal to be automatically transferred (bypassing heads) to output during "Fast Forward," "Rewind," "Record/Reverse," and "Stop."

UNIPOLAR OPERATION

The amplitude of unipolar signals recorded and reproduced may be effectively doubled by offsetting the FM carrier by jumper selection, to either plus or minus 40% deviation for an input signal level of zero volts. Likewise, by jumper selection, an offset FM carrier of either plus or minus 40% can provide an output signal level of zero volts.

DUPLICATION OPERATION

To minimize degradation of data due to demodulation of the FM carrier and regeneration of another carrier, these processes may be bypassed. The modulated FM carrier can be made available at the normal data output connector by jumper selection. Similarly, a modulated FM carrier can be connected to the normal data input connector, and by jumper selection, recorded in a direct manner onto tape.

Table 1-1. Specifications (Continued)

DIRECT RECORD/REPRODUCE SPECIFICATIONS (USING 3M-888 TAPE) OR EQUIVALENT

PASSBAND AND SIGNAL TO NOISE RATIO

Tape Speeds (ips)	Passband (±3 dB)[1]		S/N Ratio (dB)[2]	
	3964A	3968A	3964A	3968A
15	70 – 64,000 Hz	500 – 64,000 Hz	38	36
7-1/2	50 – 32,000 Hz	250 – 32,000 Hz	38	36
3-3/4	50 – 16,000 Hz	100 – 16,000 Hz	38	36
1-7/8	50 – 8,000 Hz	100 – 8,000 Hz	38	36
15/16	50 – 4,000 Hz	100 – 4,000 Hz	38	36
15/32	50 – 2,000 Hz	100 – 2,000 Hz	37	35

[1] Referenced to 10% of upper bandedge.

[2] Referenced to a 500 Hz sine wave with a maximum of 1% third harmonic distortion when reproduced at 3-3/4 ips.

INPUT LEVEL

1V to 30V (peak-to-peak).

INPUT IMPEDANCE

100K ohms nominal, single-ended.

OUTPUT LEVEL

0.5 to 5V (peak-to-peak); continuously adjustable.

OUTPUT IMPEDANCE

50 ohms nominal, single-ended (minimum load impedance 600 ohms).

CALIBRATOR

SIGNAL SOURCE

Pushbutton selectable internal or external signal source.

INTERNAL SIGNAL SOURCE

Peak AC and ± DC levels of 0, 1.0, 1.414, 2.5, 5.0 and 10.0 volts.

LEVEL ACCURACY

±2% of selected voltage.

AC FREQUENCY

500 Hz ±5% <0.25% second or third harmonic distortion.

SIGNAL MONITORING

METER MODES

Peak AC or DC (selected by front panel switch).

METER ACCURACY

Better than ±1/2 dB for signals with 20 – 100% duty cycle.

SELECTOR

Front panel pushbuttons selects metered channel.

VOICE CHANNEL

MODE OF OPERATION

Channel four (3964A) and eight (3968A) have three modes of operation; data only, voice only, and data interrupted by voice.

MICROPHONE

Dynamic, hand-held, with press-to-talk switch.

RECORD LEVEL

Automatic leveling.

MONITORING

Built-in speaker, headphone jack.

Table 1-1. Specifications (Continued)

GENERAL SPECIFICATIONS

SIZE

3964A: 40 cm (15-3/4 inches)^H X 42.6 cm (16-3/4 inches)^W X 24.8 cm (9-3/4 inches)^D.

3968A: 45.1 cm (17-3/4 inches)^H X 42.6 cm (16-3/4 inches)^W X 24.8 cm (9-3/4 inches)^D.

WEIGHT

3964A – 29.5 kg (65 lbs)
3968A – 31.3 kg (69 lbs)

POWER REQUIREMENTS

Standard, 100, 120, 220 or 240 Vac +5 -10%, 48-480 Hz, 110W average. (Option 009 and 010 instruments limited to 48-66 Hz).

TEMPERATURE

Storage	-40°C to 75°C
Operating	0°C to 55°C
Tape Limit	10°C to 40°C

ALTITUDE

Storage	50,000 feet
Operating	15,000 feet

HUMIDITY

Excluding tape limitations, it will operate from 10% to 95% RH (25°C to 40°C), non-condensing.

SHOCK

30g maximum (11 ms) non-operating.

MOUNTING

Supplied with rack mounting kit for standard 19-inch equipment racks.

1-45. OTHER ACCESSORIES.

1-46. The following accessories may be ordered:

a. TRANSIT CASE. For Model 3964A Transit Case 13107A or Model 3968A Transit Case 13106A provide protection for recorders while in tranportation.

b. TAPE DEGAUSSER. Model 13064A Tape Degausser may be used for tape erasure. One model (Option 001) operates with 115 Vac 50-60 Hz; a second model (Option 002) is used with 230 Vac 50-60 Hz.

1-47. OPTION 030, FM RECORD/REPRODUCE PCA.

1-48. The Option 030 PCA is used with Option 009 or Option 010 instruments only. The PCA is identical to the Option 010 instruments only. The PCA is identical to the Option 001 PCA, except it has no input or output connectors.

1-49. OPTION 031, DIRECT RECORD/REPRODUCE PCA.

1-50. The Option 031 PCA is used with Option 009 or Option 010 instruments only. The PCA is identical to the Option 002 PCA, except it has no input or output connectors.

Table 1-2. Field Installation of Optional Equipment

OPTION	DESCRIPTION	PART INSTALLATION KIT NUMBER	ESTIMATED TIME TO INSTALL	INSTALLATION INSTRUCTION PART NUMBER
001	FM Record/Reproduce (not compatible with Options 009, 010)	03964-60505	1 Hour (including calibration)	None
002	Direct Record/Reproduce (not compatible with Options 009, 010)	03964-60510	1 Hour (including calibration)	None
003	Rear Connector Panel	03964-60921 (All 3964A) 03968-60921 (Only 3968A Serial Prefix 1620 and above)	0.3 Hour	03964-90001 (3964A) 03968-90016 (3968A)
004	Locking Knobs	03968-20030 (4-3964A; 8-3968A)	0.1 Hour	None
005	Metric Speed Identification	03968-60914	0.2 Hour	None
007	HP-IB Interface	03968-60900	1.0 Hour	03968-90014
009	UL-544 Listed, White Paint	Not Field Installable	N/A	N/A
010	UL-544 Listed, Standard Paint	Not Field Installable	N/A	N/A
021	DC and AC Power	Must be ordered at time of recorder purchase	N/A	N/A
024	Loop Adapter Kit	13062A	0.5 Hour	03960-90020
026	Rack Slide Kit (Standard)	03964-60905 (3964A) 03968-60905 (3968A)	1 Hour	03964-90003 (3964A) 03968-90010 (3968A)
027	Rack Slide Kit (HP cabinet)	03964-60910 (3964A) 03968-60910 (3968A)	1 Hour	03964-90004 (3964A) 03968-90011 (3968A)
030	Option 009, 010 FM Record/Reproduce PCA (not compatible with standard instrument)	03968-60019	1 Hour (including calibration)	None
031	Option 009, 010 Direct Record/Reproduce PCA (not compatible with standard instrument)	03968-60018	1 Hour (including calibration)	None
041	IRIG Servo Reference Frequency	03964-60940 (3964A) 03968-60940 (3968A)	2 Hours	03964-90002 (3964A) 03968-90013 (3968A)
070	Overlap	03968-60930	4 Hours	03968-90015

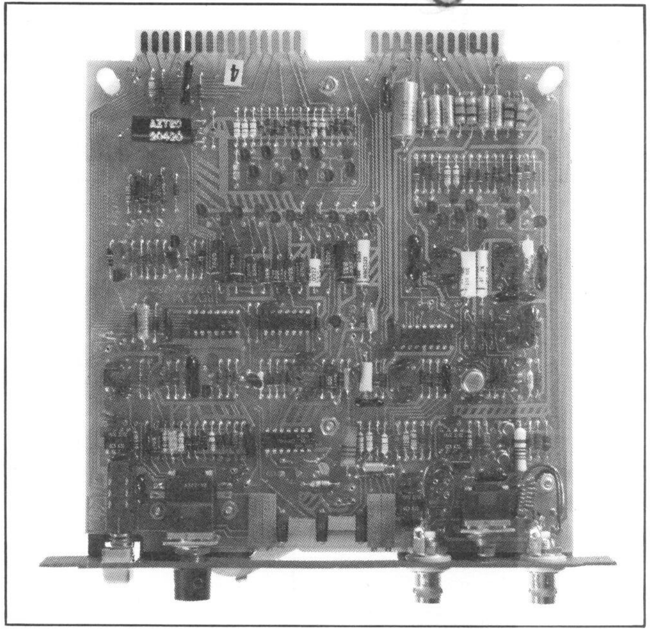


Figure 1-2. Option 001, FM Record/Reproduce PCA

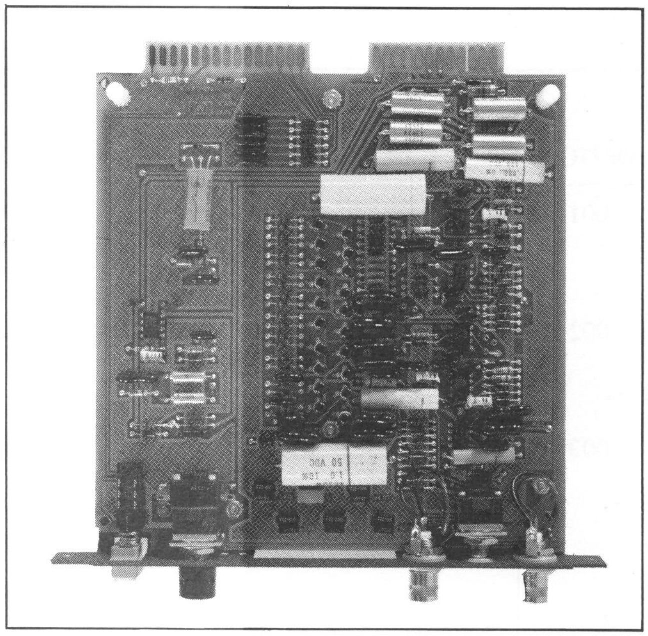


Figure 1-3. Option 002, Direct Record/Reproduce PCA

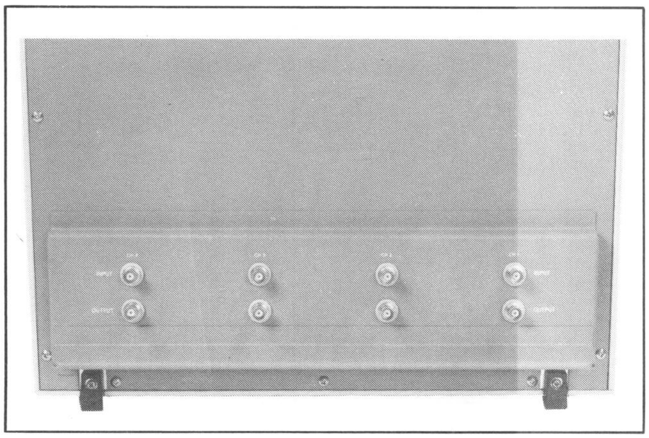


Figure 1-4. Option 003, Rear Panel Data Connectors

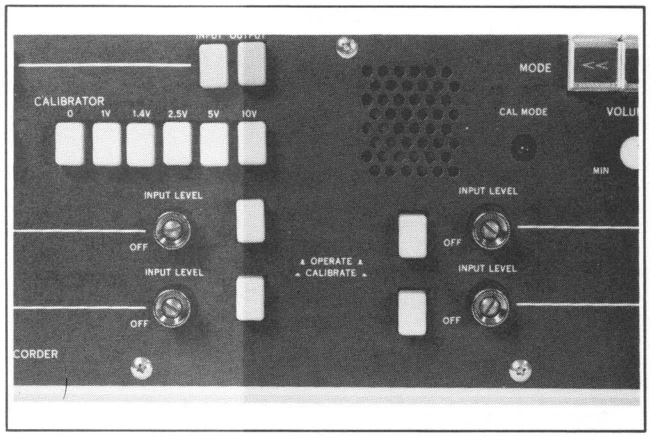


Figure 1-5. Option 004, Locking Knobs

Table 1-3. Accessories Supplied

DESCRIPTION	HP PART NO.	QTY	DESCRIPTION	HP PART NO.	QTY
Microphone	0960-0316	1	Magnetic Head Cleaner	8500-1251	1
50-Pin Connector	1251-0086	1	Cotton Applicators (Package of 100)	8520-0023	1
Accessory Case	1540-0182 (See Table 6-1)	1	Tuning Tool	8710-0957	1
Reel, Magnetic Tape	1490-0894	1	Spacer Panel, 1-3/4 inches	03968-00061	1
2300 ft of Magnetic Tape (3M-888)	9162-0066	1	Rack Mount Bracket (Mounted on recorder)	03968-20401	2
Lamp, Incandescent, 24V	2140-0452	10	Control Extender PCA	03968-60960	1
Power Cord ⟨1⟩	8120-1378	1	Data Extender PCA	03968-60965	1
Jumper Cables	8120-2233	2	Operating & Service Manual	03964-90007	1

⟨1⟩ Standard 115 Vac power cord listed; however, other power cords can be provided. Refer to paragraph 2-26 and Figure 2-8 for additional information.

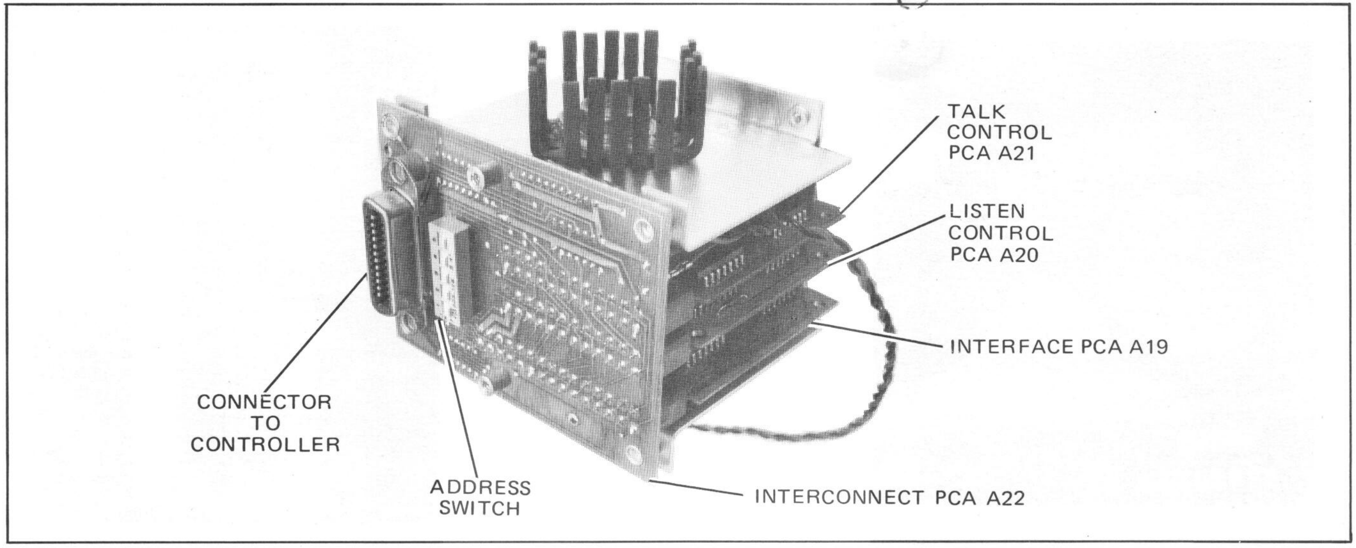


Figure 1-6. Option 007, HP-IB Interface Assembly

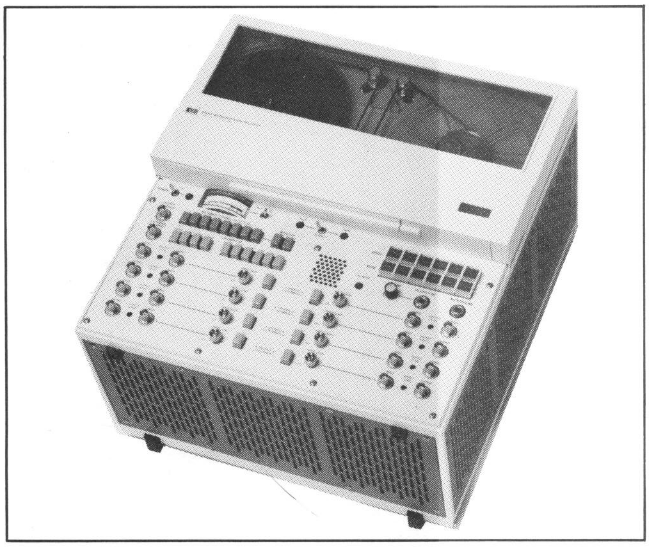


Figure 1-7. Option 009, White Paint

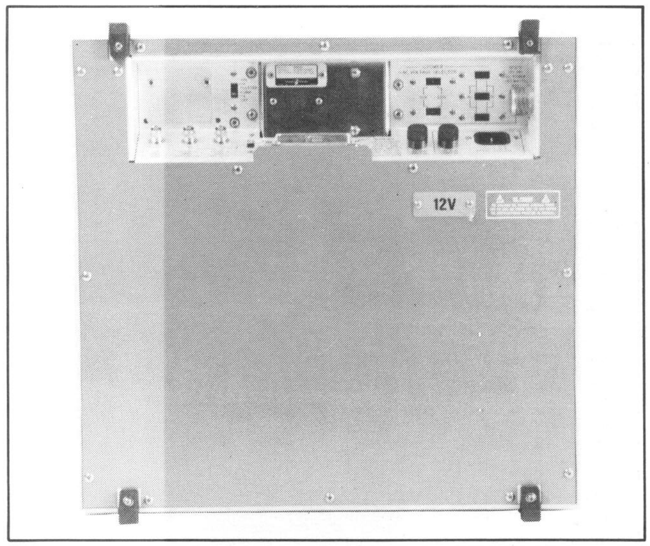


Figure 1-8. Recorder With Option 021, Rear View


Figure 1-9. Option 024, Model 3964A/3968A with Tape Loop Adapter

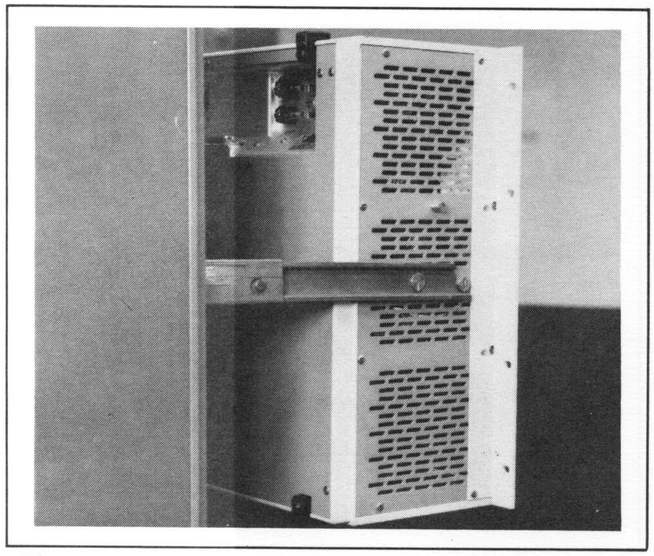


Figure 1-10. Option 026, Rack Slides for 19-Inch Cabinet

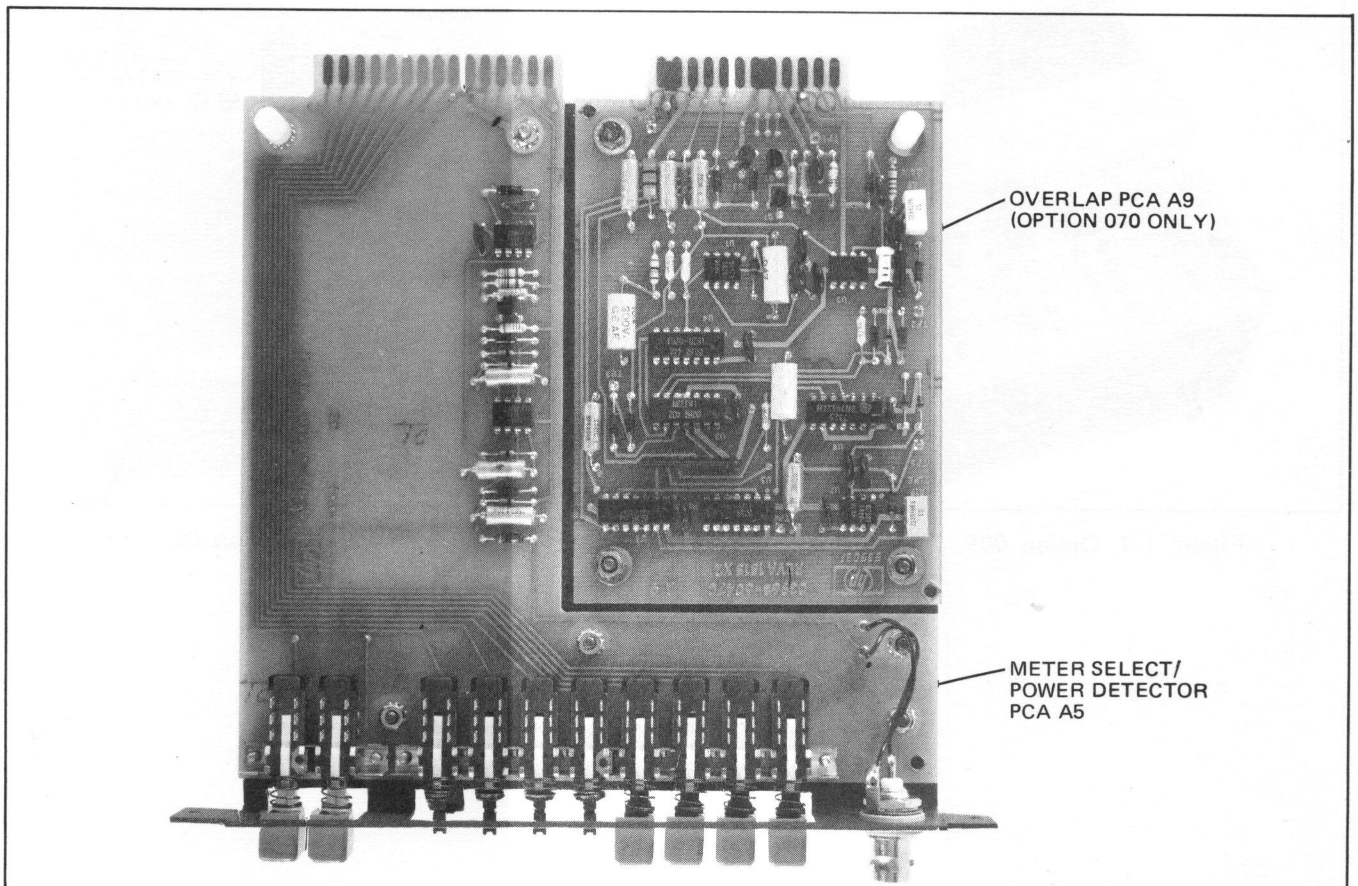


Figure 1-11. Option 070, Overlap PCA A9

Figure 1-12. Accessories Supplied

SECTION II

INSTALLATION

2-1. INTRODUCTION.

2-2. This section provides instructions for installation of the recorder. Included are instructions for incoming inspection, damage claims, preparation for use, front-panel connections, rear-panel connections, option installation, power requirements, storage, and shipment.

2-3. INCOMING INSPECTION.

2-4. Upon receipt of the packaged instrument, inspect the shipping carton for damage or indication of severe stress. If the shipping carton is damaged upon receipt, request the carrier's agent be present when the instrument is unpacked. Inspect the instrument for cracks, broken parts, scratches, and dents. Refer to the operational checkout procedures in Section V to verify correct operation of the instrument.

2-5. DAMAGE CLAIMS.

2-6. If the instrument has been damaged during shipment, notify the carrier and nearest Hewlett-Packard Sales and Service Office immediately. A list of the Sales and Service Offices is listed at the back of this manual. Retain the shipping carton and padding material for the carrier's inspection.

2-7. PREPARATION FOR USE.

2-8. The tape recorder is shipped without the tape or reels installed. Refer to Section III for standard tape loading and threading.

2-9. RACK MOUNTING BRACKETS.

2-10. The standard instrument is shipped with rack brackets installed. The rack brackets facilitate mounting in a 19-inch equipment rack. See Figure 2-1 for details.

CAUTION

The Model 3964A/3968A is cooled by convection. To avoid overheating, the instrument should be located where air circulation through the slotted top and side covers if possible. A filler panel (provided with the instrument) must be installed if the unit is rack mounted. The filler panel must be installed directly above the recorder (see Figure 2-1). Installation of the filler panel assures proper convection cooling for the instrument and prevents recorder damage from overheating.

2-11. BENCH TOP OPERATION.

2-12. If the unit is to be used in bench top configuration, remove the rack mounting brackets from the instrument by removing the six screws from each bracket (see Figure 2-1).

NOTE

Retain rack mounting brackets. Brackets are needed for shipping the recorder as well as rack mounting.

2-13. FRONT PANEL CONNECTIONS.

2-14. BNC input/output connectors are located on the front panel. Parallel rear BNC input/output connectors are available as Option 003. Record/Reproduce printed circuit assemblies (PCA's) identified as assemblies A11 through A18 (3968) and A11 through A14 (3964) with INPUT and OUTPUT BNC connectors are provided for each data channel. The OPERATE/CALIBRATE controls have the letters FM (Frequency

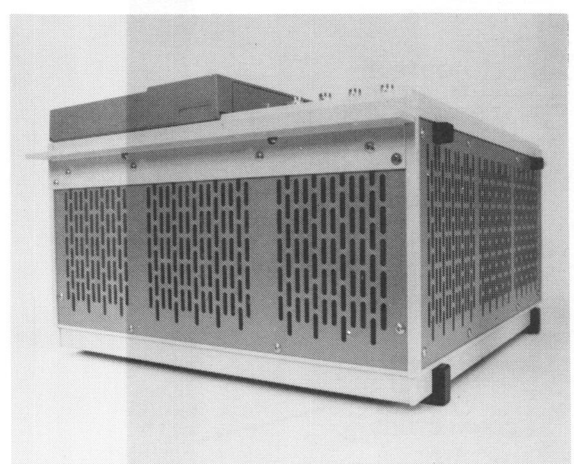


Figure 2-1. Model 3964A/3968A Standard Rack Mounting

Modulation) marked on the face of the button if Option 001 is ordered. If Option 002, Direct Record/Reproduce, is ordered, the OPERATE/CALIBRATE controls have the letter D marked on the face of the button. (See Figure 2-2.) An OUTPUT MONITOR connector can be used to monitor the output data from any data channel selected by use of the METERED CHANNEL SELECTOR switch. The EXTERNAL CAL INPUT connector allows the operator to supply an external reference into any channel of the recorder for calibration purposes. The EXT INPUT light gold button in the CALIBRATOR switch must be pushed to apply the external reference to the data channels. A headphone jack and a microphone jack are standard features. A microphone is provided in the Accessory Kit; a headphone must be purchased separately.

2-15. REAR PANEL CONNECTIONS.

2-16. Three connectors (see Figure 2-3) provide for AC power input, remote control unit connections and HP-IB (Hewlett-Packard Interface Bus) Option 070 if installed in the recorder. A 50-pin connector provides remote control connection for systems use and is discussed in paragraph 2-17. A 24-pin connector is used with an HP-IB controller, and is discussed in paragraph 2-19. If the rear data connector panel (Option 003) is installed eight BNC connectors, mounted in a separate area at the back of the instrument, provide signal inputs and outputs from the rear of the instrument (see Figure 1-4).

2-17. REMOTE CONTROL CONNECTOR.

2-18. The remote control connector is provided for the interchange of remote control signals from the control unit to recorder and status indications from the recorder to the control unit. All control and status lines are TTL compatible with a TTL low or contact closure to common for more than 15 milliseconds providing the function. Figure 2-4 shows the remote control connector wiring and a typical remote control installation. The signals that are passed between the two circuits are listed in Table 2-1 with their functions.

2-19. HP-IB INTERFACE CONNECTOR.

2-20. A controller is interfaced to the recorder through an interface connector on the rear panel (see Figure 2-5). Three interconnecting cables are available for use when the option is installed:

HP PART NO.	LENGTH
10631A	3 feet (.91 meters)
10631B	6 feet (1.82 meters)
10631C	12 feet (3.65 meters)

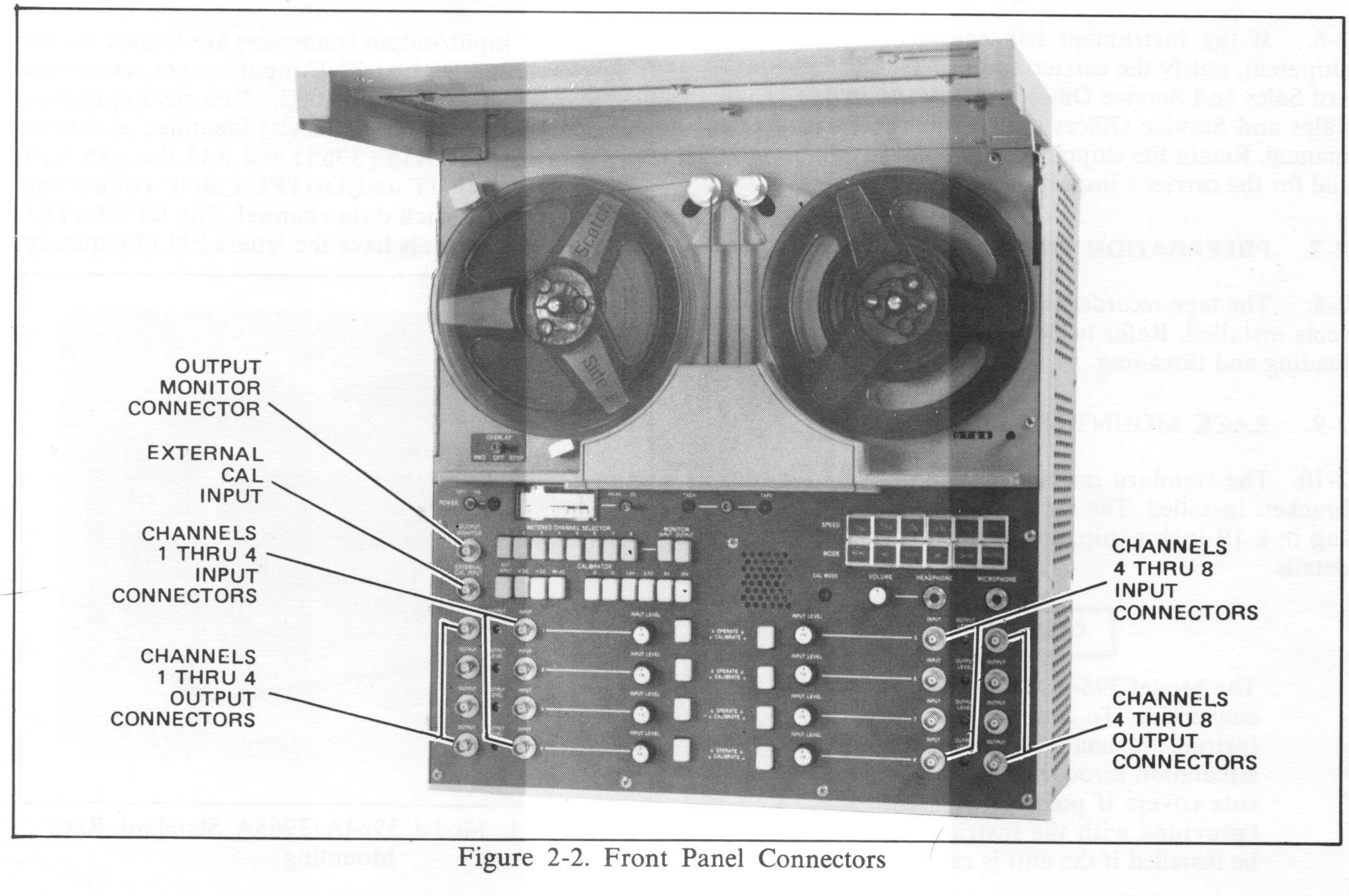


Figure 2-2. Front Panel Connectors

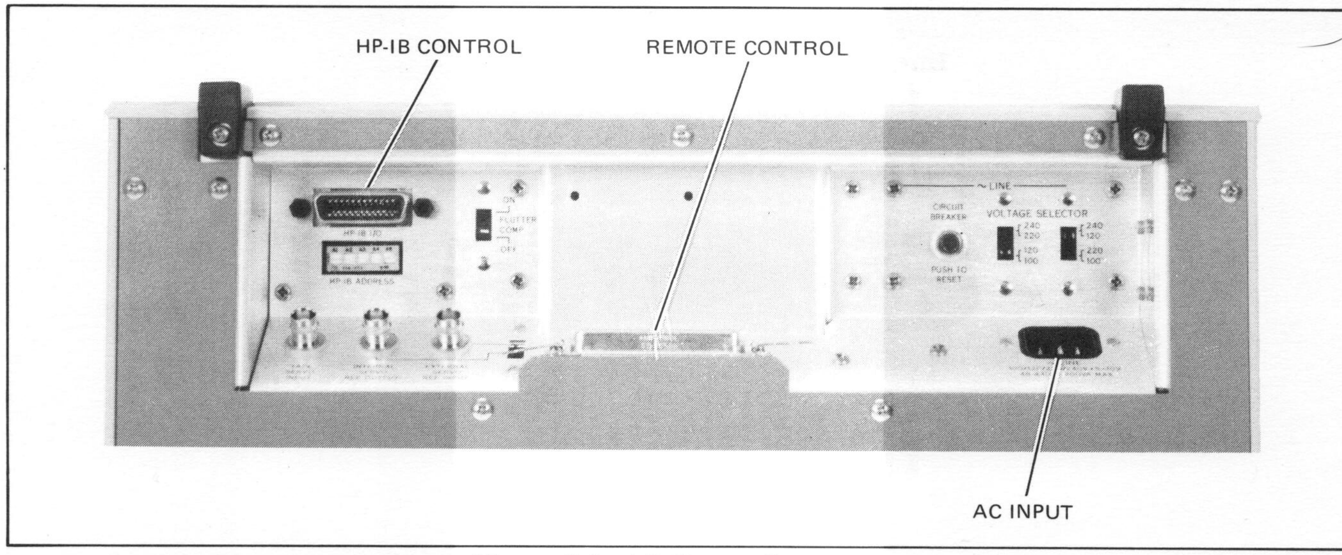


Figure 2-3. AC Power Connector

2-21. An illustration of system connection for HP-IB operation is shown in Figure 2-5, and a listing of HP-IB control and data functions is contained in Table 2-2.

2-22. OPTION INSTALLATION.

2-23. Table 1-2 lists the options that can be installed in the field, the Part Numbers of the Installation Instructions and Installation Kits available for each option, and the time required to install the option.

2-24. AC POWER REQUIREMENTS AND CONNECTIONS.

2-25. The Model 3964A/3968A operates with ac power that is selected by use of the power switch on the rear panel (see Figure 2-6). The following voltage sources can be used: 100V, 120V, 220V or 240V, 48 to 66 Hz. The AC line input is provided with a single circuit breaker for all voltage inputs. The circuit breaker has a push to reset button extending through the back panel.

2-26. The ac power cord (Part Number 8120-1378) supplied with the recorder complies with Underwriter Laboratories Inc. (UL) requirements only when used with power sources of nominally 115 Vac. For nominal 230 Vac line operation, the power cord must be replaced or modified. To modify the cord for 230V operation in the U.S., replace the 115V plug with a UL-approved 250 Vac plug as shown in Figure 2-7. Figure 2-8 shows the power plugs that are used in the United States and other countries. The plug rating and HP Part Number for the plug and power cord are shown beside each plug.

2-27. STORAGE.

2-28. When the Model 3964A/3968A is to be stored for an extended period of time, perform the following procedures:

a. Remove the tape reels from the recorder.

b. Place the tape reels in the tape box and store them in an area that is cool and free of humidity.

c. Place the reel cover over the face of the unit.

d. Cover the Model 3964A/3968A with a clean protective cloth and store in a cool dry area.

2-29. SHIPMENT.

2-30. To ship the Model 3964A/3968A, request a special shipping container from your Hewlett-Packard office. The rack ears must be installed before shipping for proper protection of the recorder when in transit. If the instrument is being returned to Hewlett-Packard for repair, do not send the power cord, or other operating accessories.

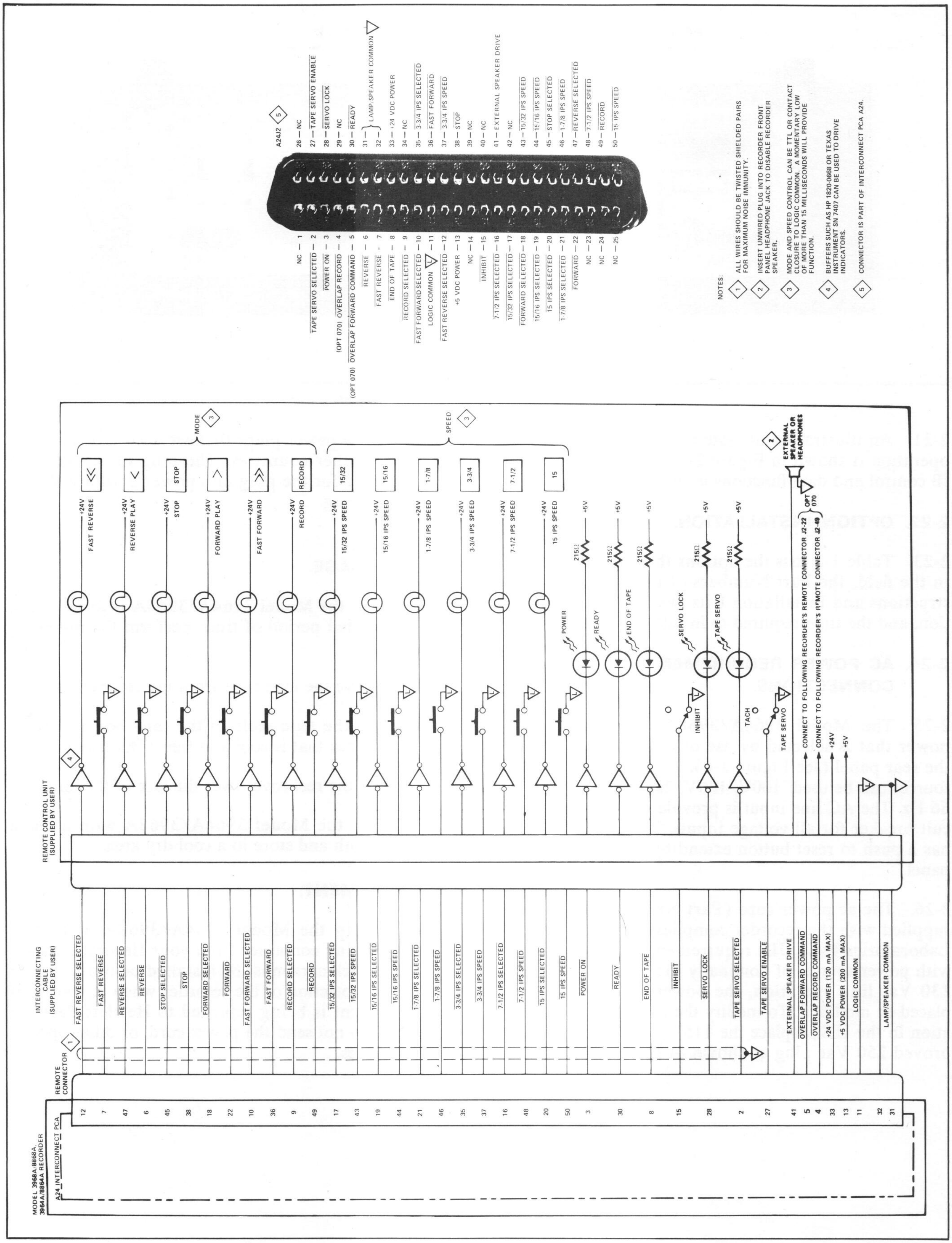


Figure 2-4. Remote Control Connector and Typical Installation

Table 2-1. Remote Control Functions

SIGNAL NAME	FUNCTION
FAST REVERSE; REVERSE; FORWARD; FAST FORWARD; RECORD; STOP	Mode Control. Sets recorder for operation in the mode selected.
FAST REVERSE SELECTED; REVERSE SELECTED; FORWARD; SELECTED; FAST FORWARD; SELECTED; RECORD SELECTED; STOP SELECTED	Provides indication of recorder mode operation.
15/32 IPS SPEED; 15/16 IPS SPEED; 1-7/8 IPS SPEED; 3-3/4 IPS SPEED; 7-1/2 IPS SPEED; 15 IPS SPEED	Sets the recorder to move tape at the speed (in inches per second) selected.
15/32 IPS SELECTED; 15/16 IPS SELECTED; 1-7/8 IPS SELECTED; 3-3/4 IPS SELECTED; 7-1/2 IPS SELECTED; 15 IPS SELECTED	Provides indication of recorder speed operation.
POWER ON	Indicates the recorder has completed a power-on initialization cycle and is ready for operation.
READY	Signal is low when recorder is operational, and is high when recorder is in a calibrate mode.
END-OF-TAPE	Indicates the loss of tape tension in the recorder. This can be due to running out of tape, improper tape tensioning before operation, or a tape break.
INHIBIT	Provision to permit a remote control unit to inhibit use of the front-panel mode and speed control pushbuttons. Active when low.
SERVO LOCK	Indicates the tape servo system is operating correctly when low. When high, indicates that the servo system is out-of-lock.
TAPE SERVO SELECTED	Indicates that the recorder is operating in the tape servo mode.
TAPE SERVO ENABLE	Remote control used to place recorder in the tape servo mode. For operation in this mode, the TACH-TAPE switch on the recorder must be in the TACK position and the RECORD, FAST FORWARD and FAST REVERSE lines must be inactive (high).
EXTERNAL SPEAKER DRIVE	This output provided to drive an external speaker or headphones. The recorder panel speaker is disabled by inserting an unwired plug into the front-panel HEADPHONE jack.

Table 2-1. Remote Control Functions (Continued)

SIGNAL NAME	FUNCTION
$\overline{\text{OVERLAP FORWARD COMMAND}}$	Occurs only when Option 070 is installed. A momentary low provided when tape end is sensed on the recorder. Used to set the following recorder in a forward mode. In overlap operation, connected from A24J2-5 in the first recorder to A22J2-22 in the second recorder.
$\overline{\text{OVERLAP RECORD COMMAND}}$	Occurs only when Option 070 is installed. A momentary low provided when tape end is sensed in the recorder. Used to set the following recorder in the record mode. In overlap operation, connected from A24J2-4 in the first recorder to A24J2-49 in the following recorder.
+24 Vdc Power	A +24V, 120 mA power source for use with 24V indicator lamps in a remote control unit.
+5 Vdc Power	A +5V, 200 mA (maximum) source for use with integrated circuit buffers and LED indicators.
Logic Common	Return to be used with control switches and TTL logic to minimuze transients.
Lamp/Speaker Common	Normally used for higher current returns.

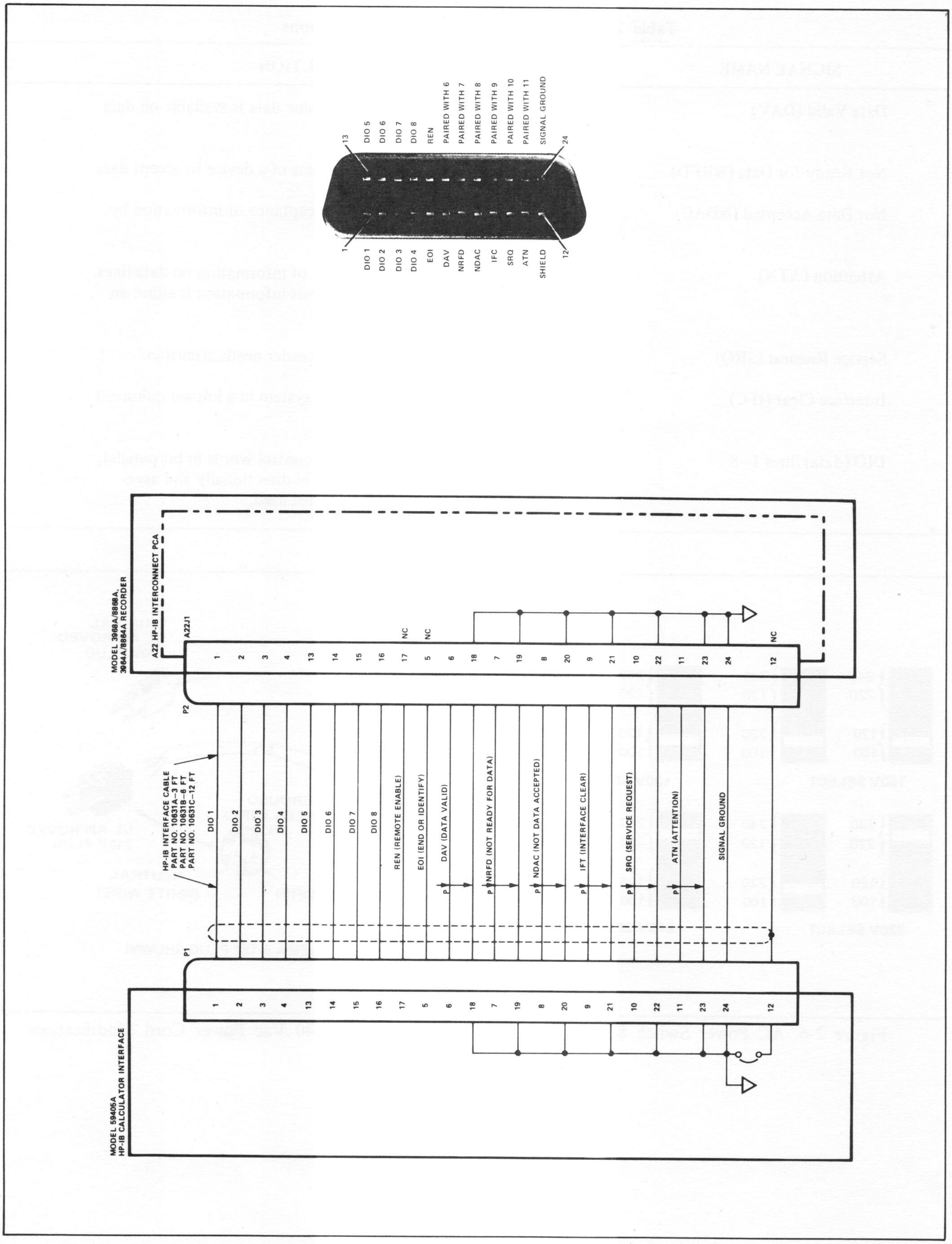


Figure 2-5. HP-IB Interface Connector and Typical Installation

Table 2-2. HP-IB Control and Data Functions

SIGNAL NAME	FUNCTION
Data Valid (DAV)	When true, indicates that value data is available on data (DIO) lines.
Not Ready for Data (NRFD)	When true, indicates readiness of a device to accept data.
Not Data Accepted (NDAC)	When true, indicates the acceptance of information by a device.
Attention (ATN)	Used to identify the nature of information on data lines. In the Model 3968A, data bus information is either an address or control word.
Service Request (SRQ)	When true, indicates the recorder needs attention.
Interface Clear (IFC)	Used to place the interface system in a known quiescent state.
DIO (data) lines 1–8	Used to carry 8-bit data or control words in bit parallel, byte serial. Words are sent bi-directionally and asynchronously. DIO line 8 is not used.

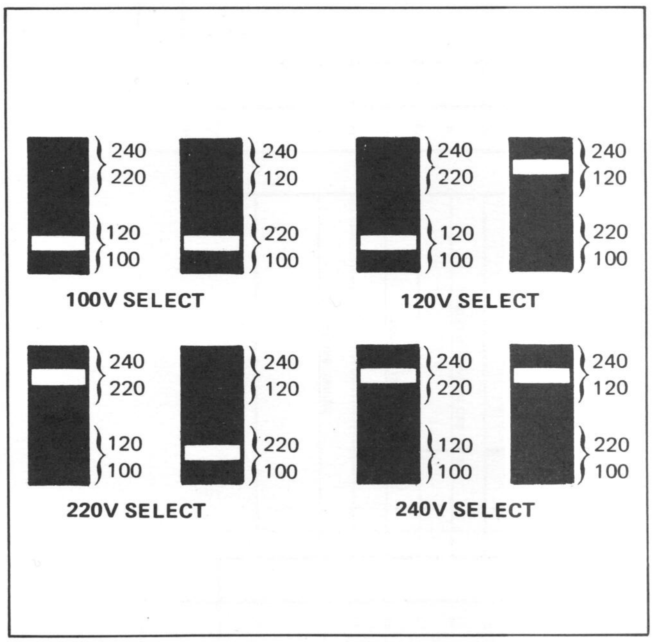


Figure 2-6. AC Power Switch Settings

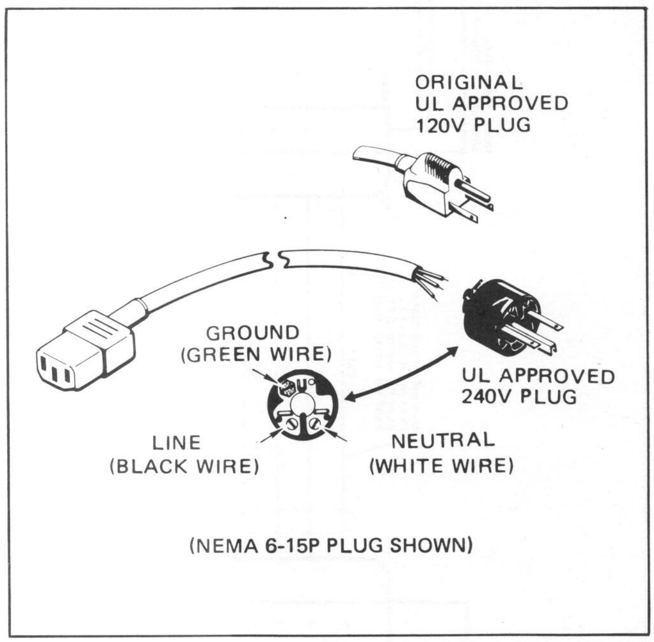


Figure 2-7. 240 Vac Power Cord Modification

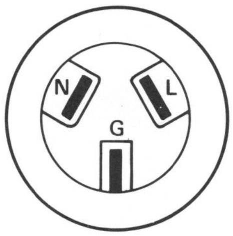
Option Number

BS 1363A

HP Part Number 8120-1351; 250V, 13A, 1ϕ plug rating. 900

(Furnished for use in Great Britain, Cyprus, Nigeria, Rhodesia, Singapore)

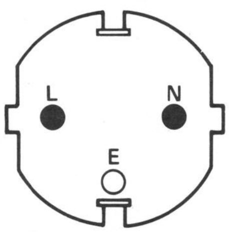
AS C112



HP Part Number 8120-1369; 250V, 10A, 1ϕ plug rating. 901

(For use in Australia, New Zealand)

CEE 7-VII



HP Part Number 8120-1689; 250V, 10/16A, 1ϕ plug rating. 902

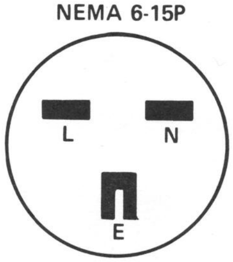
(Furnished for use in East and West Europe, Saudi Arabia, Egypt)

NEMA 5-15P

HP Part Number 8120-1378; 125V, 15A, 1ϕ plug rating. 903

(UL approved; furnished with standard for use in United States, Canada, Japan, Mexico, Philippines, Taiwan)

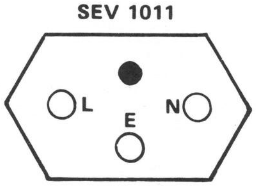
NEMA 6-15P



HP Part Number 8120-0698; 250V, 15A, 1ϕ plug rating. 904

(UL approved; for use in United States)

SEV 1011



HP Part Number 8120-2104; 250V, 10A, 1ϕ plug rating. 906

(For use in Switzerland)

NOTE: All plugs are viewed from connector end; E is earth or safety ground, N is neutral or identified conductor, and L is line or active conductor.

Figure 2-8. Power Plug Configurations and Part Numbers

SECTION III

OPERATION

3-1. INTRODUCTION.

3-2. This section provides operating instructions for the Model 3964A/3968A Instrumentation Tape Recorder. Included herein are listings of front and rear panel controls, connectors and indicators, electrical requirements, operator maintenance procedures, and operating procedures for various recorder configurations.

3-3. CONTROLS, CONNECTORS AND INDICATORS.

3-4. Front panel controls, connectors and indicators are illustrated and described in Figure 3-1. Rear panel controls and connectors are illustrated and described in Figure 3-2.

3-5. ELECTRICAL REQUIREMENTS.

3-6. The Model 3964A/3968A can operate on 100, 120, 220 or 240 Vac (all +5, -10%) 48 to 66 Hz. Power consumption is 205W maximum from an AC supply. Refer to Section II for detailed information on AC electrical connections.

3-7. SELECTING A RECORDING TAPE.

NOTE

Recalibration of any Direct Record/Reproduce PCA's (paragraph 5-76) is required when changing to a different type of tape. The FM Record/Reproduce PCA's bias must also be adjusted if bias is being used (paragraph 5-75, steps v. through y.).

3-8. The recorder has been calibrated at the factory for 3M888 Magnetic Recording Tape. This high quality instrumentation tape has been selected to give optimum performance and long head life. We recommend the use of this tape. If a different magnetic tape is being considered our recommendations are as follows:

a. First consideration should be a high quality instrumentation tape such as 3M888.

b. Second choice should be from among the highest quality audio tapes which are available.

c. Medium quality audio tapes are normally the least expensive type, but may be a less economical choice than high quality tapes because of shorter recorder head life.

d. Low quality audio tapes are not recommended.

3-9. RECORDING TAPE ENVIRONMENTAL FACTORS.

3-10. Quality magnetic tapes designed and manufactured for instrumentation recording will operate over wide ranges of temperature and humidity. Never the less, recording problems can be caused by exposing the recording tape to environmental extremes. Some suggestions are listed below:

a. An optimum range for most magnetic tapes is between 15°C and 27°C. A tape temperature limit of 10°C to 40°C is specified in Table 1-1 for the Model 3964A/3968A. Temperatures above 40°C with high humidity can cause stretching of the tape or cause the tape to stick to the capstan and become tangled. Temperatures below 10°C tend to make the tape brittle. Recording dropouts can result from poor head to tape contact.

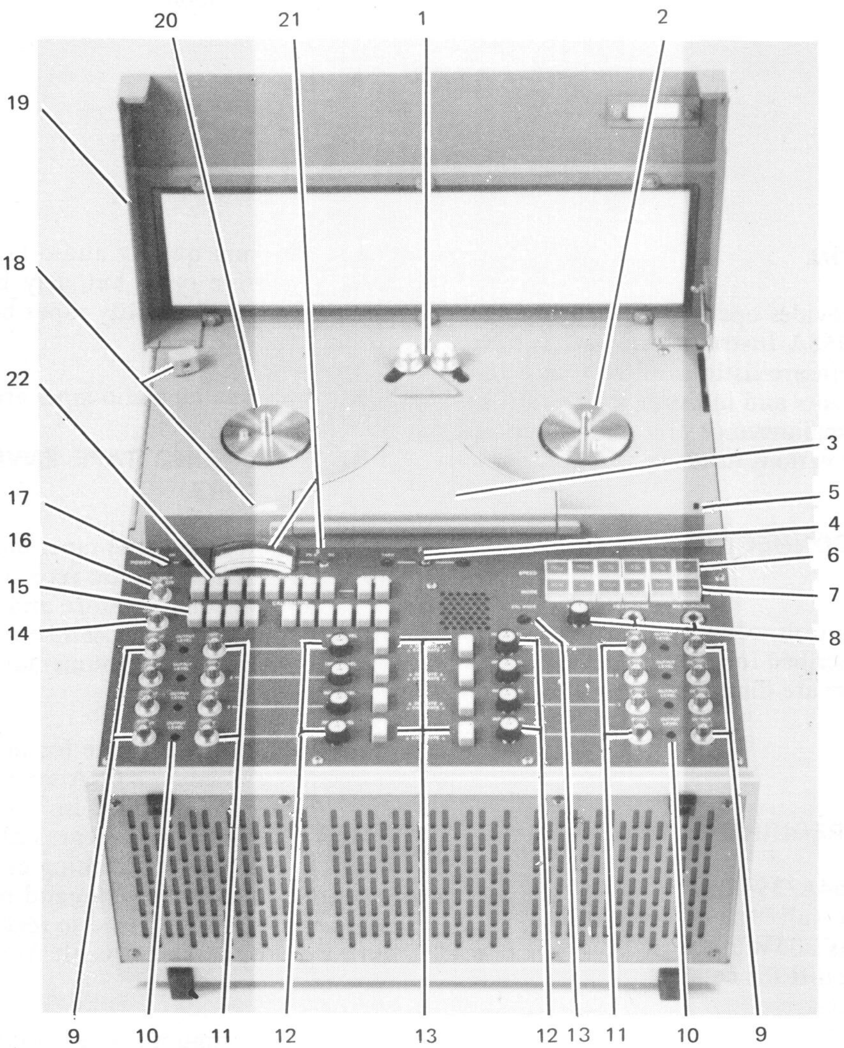
b. The optimum range for instrumentation tape is 40 to 60% RH. The humidity range specified is 10 to 95%, non condensing. High humidity can cause higher head wear. Low humidity can cause oxide shed of the tape and electro static problems.

c. Operate your recorder with the reel cover closed in a low dust environment if possible. Keeping the recording tape clean will lengthen recorder head life. Clean the heads, capstan, and tape guides before each recording.

d. Tape storage should be considered for preservation of your magnetic tapes. Tape storage is usually in the same environment of the recording. Store your tapes on edge in containers to protect from dust. If a reel has been exposed to extreme temperatures, allow eight hours to stabilize at the recording environment before using on the recorder.

3-11. TAPE LOADING AND THREADING.

3-12. Two 7-inch (or 5-inch) plastic reels are used on the recorder. Whether to load the supply reel on the left or right reel hub depends on the direction in which



1. Tension Arms. Stop transport after a momentary delay if tape tension is lost (end of tape or tape breakage). Must be pulled down to allow the tape transport to operate.

2. Right Hub. Used to retain and drive the take-up reel in > or >> operation (supply reel in < or << operation).

3. Head Cover. Protective cover for heads and capstan. Hinged at the bottom, pull out at the top for access to heads. See Figure 3-3 for head and capstan details.

4. TACH-TAPE SERVO Switch. When the switch is in the TACH position, a signal supplied by the capstan motor tachometer is used to phase-lock the capstan motor to a selected tape speed. With the switch set to TAPE, a previously recorded reference signal can be used to phase lock the capstan motor. This taped reference signal is applied through the TAPE SERVO INPUT connector on the rear panel. If the switch is set to TAPE and no tape reference input is applied to the recorder, the capstan motor phase-lock circuit automatically reverts to the TACH mode of operation.

5. Reel Revolution Counter and Reset Button. Counts revolutions of the right reel. Pressing the reset button sets the counter to 0000.

6. SPEED selector switches. Used to select the tape speed (in inches per second, or centimeters per second with Option 005) in the < or > modes. Selected speed button should light.

Figure 3-1. Front Panel Controls, Connectors and Indicators (Sheet 1 of 2)

7. MODE selector switches. Used to select the tape transport mode of operation. Modes available are:

<<	High speed right to left (fast reverse tape movement).
<	Right to left tape (reverse) movement, speed selected by SPEED selector switch. Can be used to record if RECORD and < buttons are depressed simultaneously.
STOP	Stops tape. Button will be lit in this mode only if tape is under proper tension.
>	Left to right (forward) tape movement. Otherwise the same as <.
>>	High speed left to right (fast forward) tape movement.
RECORD	Used to initiate the Record mode. Must be depressed together with the > or < button.

8. Voice channel controls and connectors. Used for annotating using channel 8 on the tape. The MICROPHONE connector is used to couple in a voice signal, and to enable record channel 8. The signal level is automatically controlled in the record section, with a VOLUME control being used to set the level of the signal output in the playback mode. There are two signal outputs; a HEADPHONE connector and a speaker. The speaker is disabled when the microphone or headphones are used.

9. OUTPUT connectors. Used to couple the tape output of each channel to other equipment or to the TAPE SERVO IN connector when using the tape servo mode.

10. OUTPUT LEVEL adjustments. Used to set the signal level present at the output connector of each channel.

11. INPUT connectors. Used to couple signals from other equipment to the recorder preamplifiers for recording. Also used to connect a reference signal from the INTERNAL REF OUTPUT connector to a data PCA during tape servo operation.

12. INPUT LEVEL controls. Used to set the recording level for each channel. A switch at the CCW end of rotation turns the channel off. A decal on the knob indicates whether the channel is of the FM or Direct (D) type.

13. OPERATE/CALCULATE switches and CAL indicator. Used to internally connect the calibrator to a data PCA input for calibration. Indicator is lighted if any channel is in calibrate. Refer to paragraph 3-92.

14. EXTERNAL CAL INPUT connector. Used to connect an external reference signal to the data PCA's. See paragraph 3-92.

15. CALIBRATOR switches. Used to determine the type and level of the internal calibrator signal available, or to allow substitution of an external signal for the internal calibrator signal. See paragraph 3-92.

16. OUTPUT MONITOR connector. Used with the METERED CHANNEL SELECTOR switches to connect the reproduce output of a selected channel to other equipment.

17. POWER switch and indicator light. Used to apply and indicate the application of primary power to the recorder.

18. Overlap switch (not shown) and end of tape sensors for overlap operation (Option 070). See paragraph 3-84.

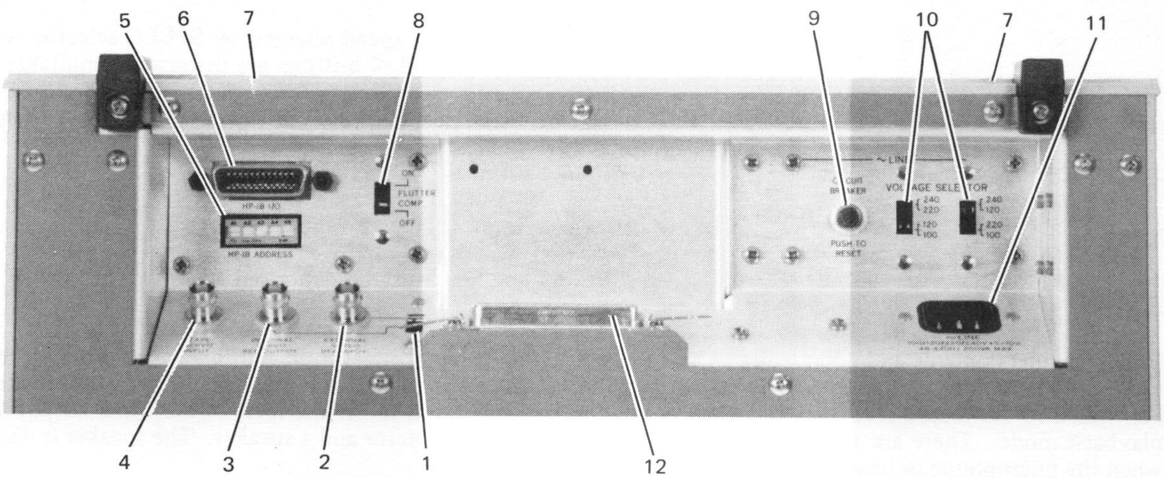
19. Reel cover. Used to protect reels, recording tape and heads.

20. Left hub. Used to retain and drive the supply reel in > or >> operation (take-up reel in < or << operation).

21. Level meter and meter function (PK-AC or DC) selector switch. Lower meter scale is for PK-AC position of the switch; upper scale is for DC calibration of FM channels. Meter monitors the channel selected by the METERED CHANNEL SELECTOR and MONITOR switches. See paragraph 3-86.

22. Signal monitoring controls. These are four METERED CHANNEL SELECTED switches, which connect the meter to one of the channels, and INPUT and OUTPUT selector switches, which determine the point in the circuit to be monitored. See paragraph 3-86.

Figure 3-1. Front Panel Controls, Connectors and Indicators (Sheet 2 of 2)



1. Servo reference switch. Controls origin of servo reference signal. See paragraph 3-35.
2. EXTERNAL SERVO REF INPUT. Input jack for external servo reference signal. See paragraph 3-35.
3. INTERNAL SERVO REF OUTPUT. Output jack for recorder servo reference signal. See paragraph 3-35.
4. TAPE SERVO INPUT. Input jack for tape servo reference signal. See paragraph 3-35.
5. HP-IB address switch. Used to set the recorder address for HP-IB interface operation. Refer to paragraph 3-54.
6. HP-IB connector. Used to interconnect HP-IB controller and recorder. Refer to HP-IB connectors in Section II.
7. Carrying handles. Used to transport the recorder short distances.

NOTE

This instrument weighs approximately 75 pounds. To avoid possible personal injury, one person should not attempt to carry the recorder unaided.

8. FLUTTER COMP switch. Used to improve signal to noise ratio during FM operation. (Refer to paragraph 3-33.)
9. AC Circuit Breaker: 1.2A. Used with all voltage sources.
10. AC VOLTAGE SELECTOR switches. These switches are used to configure the recorder for the correct AC line voltage (see Figure 2-6).
11. AC LINE input connector. Used when the recorder is being driven from an AC power line.
12. Remote control input/output connector. Used to control the recorder from a remote location. Refer to Remote Control Connections in Section II for details.

Figure 3-2. Rear Panel Controls and Connectors

you want to record. The HP Model 3964A/3968A Recorder is capable of recording and reproducing in either direction. Normally, data will be recorded in the forward direction (left reel to right reel). Load tape on the recorder as follows:

a. Place a supply reel on left reel hub and press down on reel until ball detents lock reel in place. Turn reel until button on reel hub locks into mating reel hub hole to prevent reel slippage.

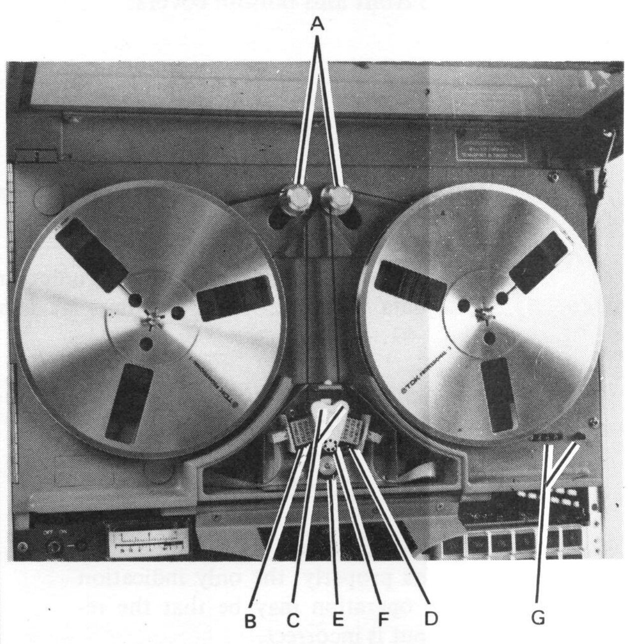
b. Place an empty reel on the right (take-up) reel hub and lock into reel hub hole.

c. Pull length of tape from supply reel over the top of the two tension arms and wind several turns of tape around the take-up reel (see Figure 3-3).

d. Place left index finger on tape, between the two tension arms and pull tape toward capstan.

e. Before reaching tape guides, place a second finger in the loop and spread tape around tape guides and capstan. Work the tape down the capstan until it touches the pinchroller.

f. Using right hand on take-up reel and left hand on supply reel, feed tape off supply reel. As tape is pulled around the guides, the tapered guide cap will work the tape down into place between the capstan and pinchroller.



A. Tension Arms
B. Record Head
C. Tape Guides (Hidden) and Interhead Shield
D. Reproduce Head
E. Pinchroller
F. Capstan (Hidden)
G. Reset Button and Counter

Figure 3-3. Tape Threading

g. Increase tension on tape until tape rollers are pulled away from rest position (STOP light will illuminate).

h. Press > (forward) or >> (fast forward) pushbutton to make sure that tape is tracking properly and running freely, then press STOP pushbutton.

i. Press reel revolution counter reset button to reset indicator to 0000.

3-13. FM OPERATION.

3-14. FM RECORD/REPRODUCE PCA JUMPERS.

3-15. Prior to operation of the Model 3964A/3968A in the FM mode, all FM Record/Reproduce PCA's should be checked for proper jumper connections. To do this, proceed as follows:

a. Turn POWER switch OFF.

b. Remove the front and bottom panels (see Details A and B, Figure 3-4).

c. Remove one FM Record/Reproduce PCA from the recorder.

d. Check the unipolar input and output jumpers (see Figure 3-5).

NOTE

For normal (bipolar) operation, the jumpers should be from "C" to "O". For unipolar operation, refer to paragraph 3-47.

e. Check the dubbing input and output jumpers. For normal operation both jumpers should be from "C" to "N". For dubbing, refer to paragraph 3-43.

f. Check the tape servo jumper. For normal operation the jumper should be from "C" to "O". For tape servo operation refer to paragraph 3-35.

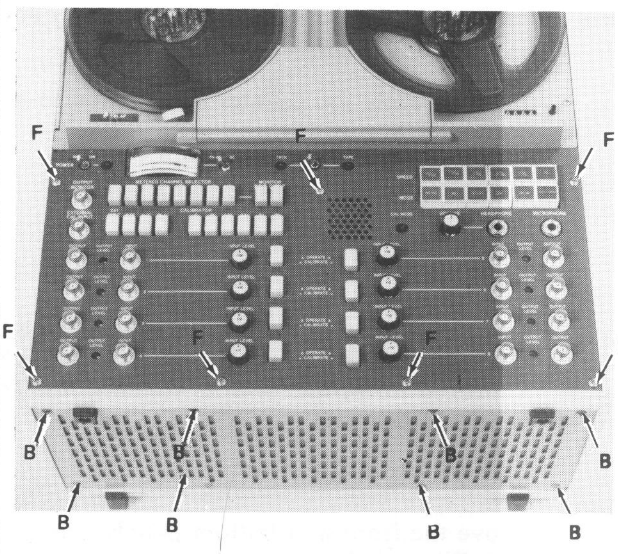
g. Check the amplitude/phase selector jumper. For normal data the jumper should be from "C" to "A". For data with fast rise and fall times, connect the jumper between "C" and "Ø".

NOTE

The FM channel cannot meet pass band specifications with the amplitude/phase selector in the phase position. Amplitude will be typically 6 dB low at upper band edge in phase.

h. Check the bias selector jumper. If all Record/Reproduce PCA's are FM, the jumper should be from

DETAIL A



DETAIL B

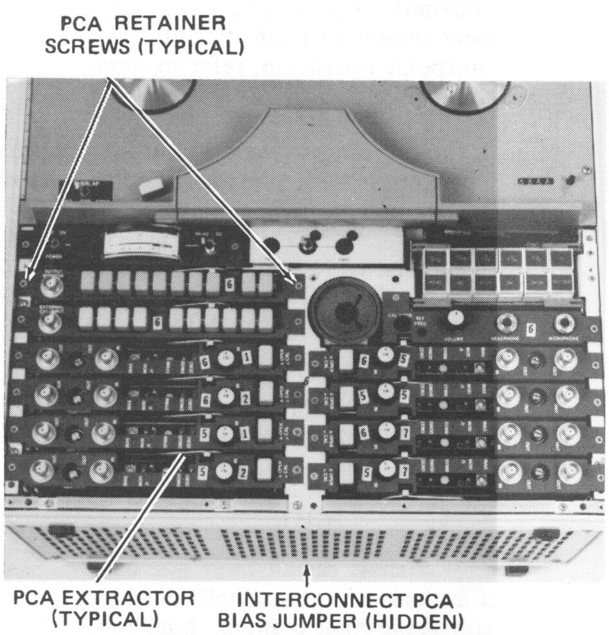


Figure 3-4. Front and Bottom Panel Removal

"C" to "NB" (non-bias operation). If any of the Record/Reproduce PCA's are Direct, the jumper should be from "C" to "B" (bias operation).

NOTE

Bias jumpers are connected and circuit board adjustments are performed at the factory according to the type data cards installed in the recorder (non-bias or bias operation). When changing from non-bias to bias operation, or vice versa, jumper changes and adjustments are required in the 3964 and 3968. Refer to paragraph 5-77 through 5-80 as applicable for instructions.

i. Check the Equalization Selector jumper. In a 3964 not using bias, (all data channels are FM) the jumper is connected between pins C and 1. In a 3964 using bias and all 3968 recorders the jumper is connected between pins C and 2.

j. Check the bias selector jumper on Interconnect PCA A24 (see Figure 3-6). If bias is not being used, the jumper is connected between pins C and NB. If bias being used, the jumper is connected between pins C and B (refer to NOTE following step h.).

k. Replace the PCA in the recorder. Repeat steps c. through i. for all other FM Record/Reproduce PCA's.

l. Replace the front and bottom covers.

3-16. FM RECORD OPERATION.

3-17. To use the recorder in the FM mode, proceed as follows for each channel:

a. Determine the peak amplitude and type (unipolar or bipolar) of the data to be recorded. For unipolar data refer to paragraph 3-47.

b. Check the jumper connections on the Record/Reproduce PCA to be used (refer to paragraph 3-14).

NOTE

If the Record/Reproduce PCA jumpers are not connected properly, the only indication of improper operation may be that the reproduce output is incorrect.

c. Set the recorder POWER switch ON and TAPE-TACH switch to TACH.

d. Using the MODE control pushbuttons, select the STOP mode.

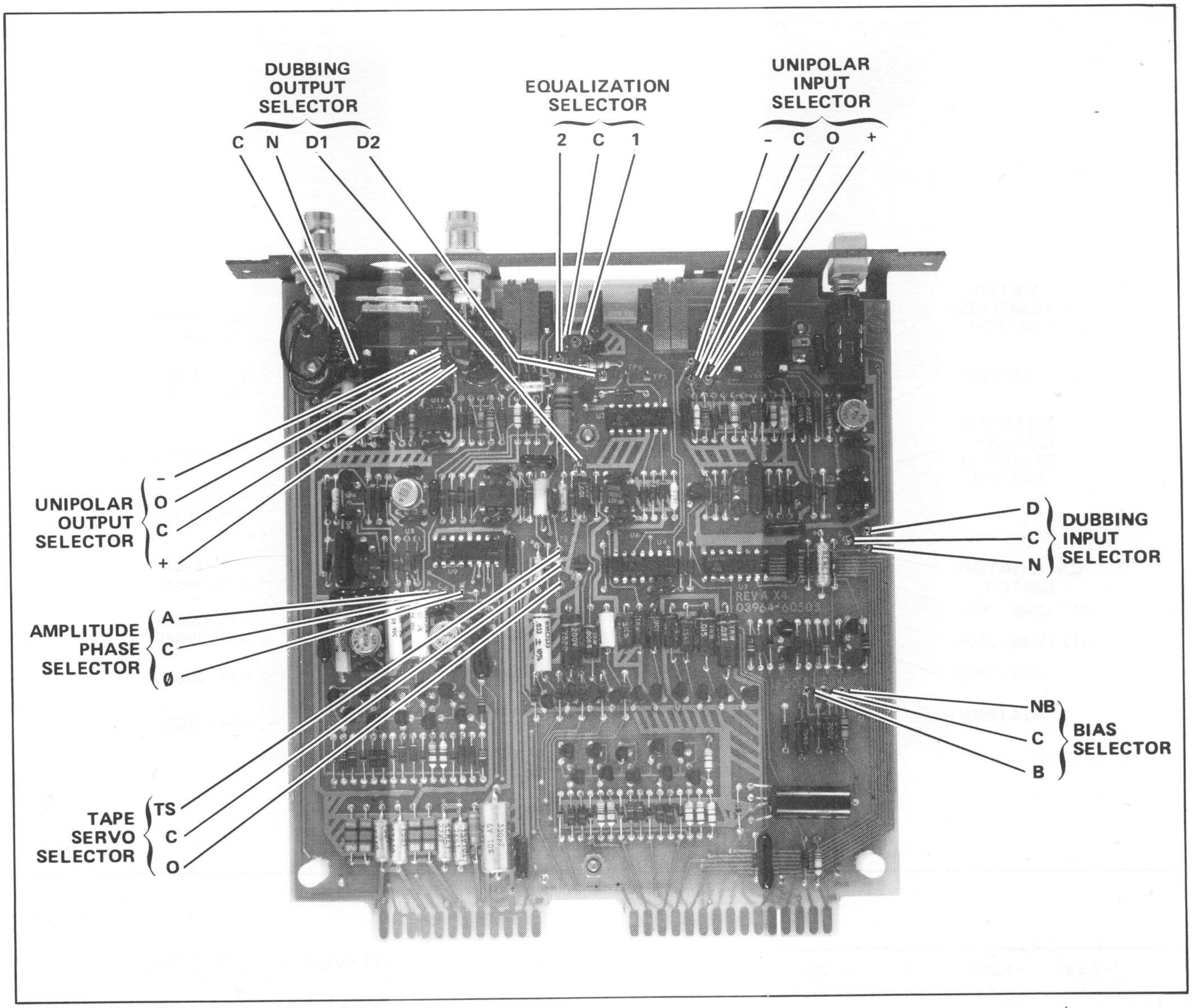


Figure 3-5. FM PCA Jumper Identification

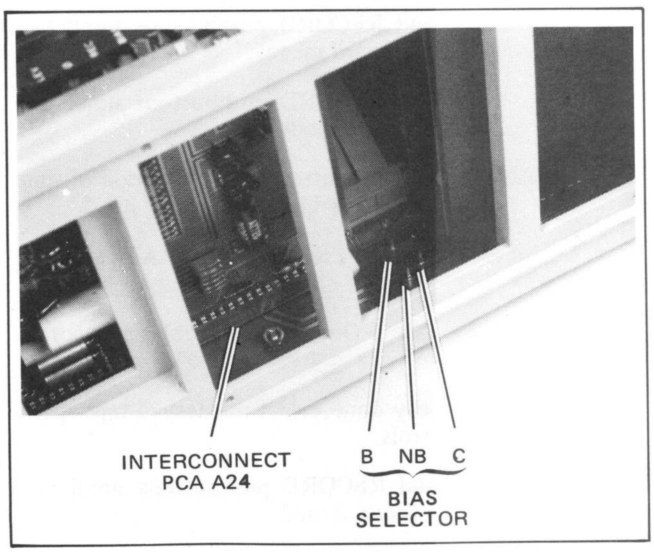


Figure 3-6. Interconnect PCA Bias Jumper Identification

e. Set the METERED CHANNEL SELECTOR switch to the desired channel, the MONITOR switch to INPUT, and the meter function switch to PK-AC (see Figure 3-7).

NOTE

Refer to paragraph 3-86 for detailed operating instructions on the use of the selector switches, calibrator and meter.

f. Set the CALIBRATOR mode and voltage switches to provide a DC calibration signal equal to the highest voltage to be recorded (determined in step a.).

g. Set the OPERATE/CALIBRATE switch associated with the channel being calibrated to CALIBRATE position.

h. Adjust the channel INPUT LEVEL control for a reading of 0 dB on the meter (see Figure 3-8). This function sets the FM deviation to 40%, thereby providing the optimum signal-to-noise ratio.

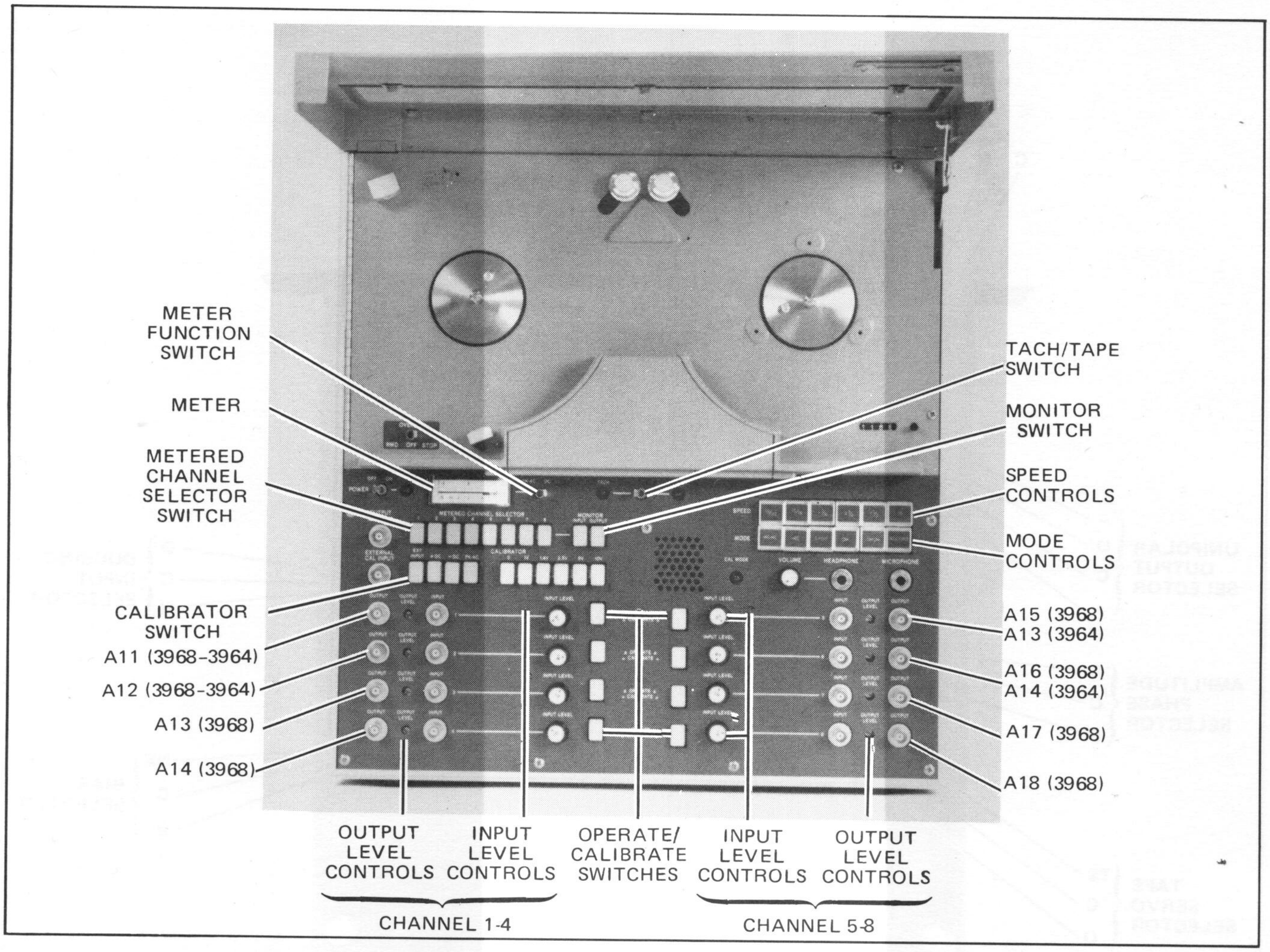


Figure 3-7. Record/Reproduce Controls

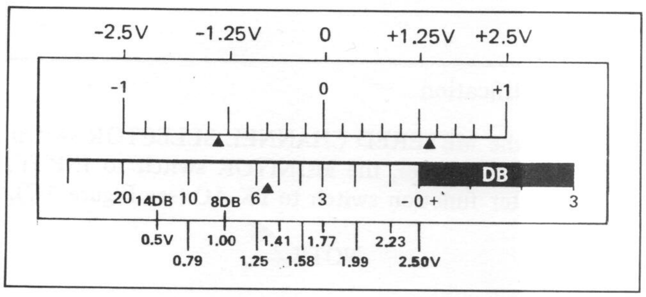


Figure 3-8. Recorder Meter Scale

i. Calibrate the record sections of the remaining FM channels using the procedures in steps e. through h.

NOTE

For calibration purposes during playback, it may be desirous to have a sample of the calibrating voltage recorded on tape before recording. If this is the case, perform steps j. through t. If not, proceed to step p. and continue with the following steps.

j. Check all FM channel OPERATE-CALIBRATE switches. The switches should be set to CALIBRATE.

k. Set the SERVO switch to the TACH position.

l. Select the desired tape speed using the SPEED controls.

m. Press the > and RECORD pushbuttons simultaneously to record in the forward mode.

n. Press the < and RECORD pushbuttons simultaneously to record in the reverse mode.

o. Press the STOP pushbutton after the period of time allotted for recording the calibrating voltage.

p. Set all FM channel OPERATE-CALIBRATE switches to OPERATE.

q. Connect Input and Output signal cables to recorder connectors.

r. If not previously done, select the desired tape speed using the SPEED controls.

s. Press the > and RECORD pushbuttons simultaneously to record in the forward mode.

t. Press the < and RECORD pushbuttons simultaneously to record in the reverse mode.

3-18. FM REPRODUCE OPERATION.

NOTE

If the calibration voltage has been recorded on the first portion of the tape, the OUTPUT LEVEL can be accurately adjusted to this reference when reproducing. If this is the case, perform steps f. through j., then step c.

3-19. To operate the FM reproduce amplifier, proceed as follows for each channel in use:

a. Adjust the FM INPUT LEVELS using the procedures in paragraph 3-17, steps a. through i.

b. Set the MONITOR switch to OUTPUT.

c. Adjust the channel OUTPUT LEVEL control for the desired peak output as indicated on the lower scale of the meter (see Figure 3-8).

d. Set the channel OPERATE/CALIBRATE switch to OPERATE.

e. Repeat steps a. through d. for each FM channel in the recorder.

f. Perform the procedures listed in paragraphs 3-23 and 3-25 for each Direct channel in the recorder.

g. Set the front panel TACH-TAPE switch to the TACH position.

h. Select the desired tape speed using the front panel SPEED controls.

i. Press the > (forward) pushbutton only to play back in the forward mode.

j. Press the < (reverse) pushbutton only to play back in the reverse mode.

NOTE

When the tape is running at the selected speed, the front panel TACH light will turn on.

3-20. DIRECT OPERATION.

NOTE

Amplitude variations and signal dropouts are characteristic when using the direct recording method. The primary advantage of direct recording is the bandwidth; however, FM is recommended for high quality recording and reproduction if wide bandwidth is not needed.

3-21. TAPE EQUALIZATION.

3-22. There are no operator adjustments to compensate for different types of tape. See Section V (paragraph 5-83) for tape equalization adjustment procedures. The Direct Record/Reproduce PCA's in the 3964A and 3968A are the same, except for jumper connections on the PCA installed in the 3964A (see Figure 3-8). For 3964A operation, the jumpers are connected between pins "C" and "4". In a 3968A, the jumpers are connected between pins "C" and "8".

3-23. DIRECT RECORD OPERATION.

3-24. To record in the Direct Mode, proceed as follows:

a. Determine the maximum signal level to be recorded. This level should be a peak AC value.

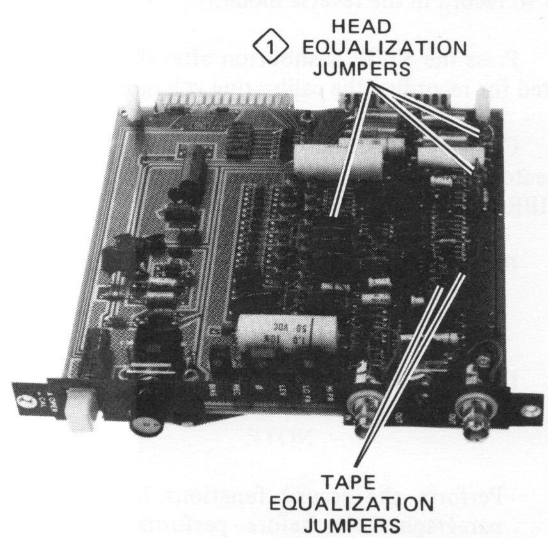
b. Set the recorder POWER switch on and TACH-TAPE switch to TACH.

c. Press the METERED CHANNEL SELECTOR switch associated with the channel to be calibrated.

d. Set the MONITOR controls for INPUT.

e. Set the meter function switch to PK-AC.

f. Set the CALIBRATOR mode and voltage switches to provide a calibration signal equal to the voltage in step a.



NOTE:

1 HEAD EQUALIZATION JUMPERS ARE USED TO COMPENSATE FOR HEAD DIFFERENCES BETWEEN THE 3964A AND 3968A. JUMPERS ARE CONNECTED AS FOLLOWS:

3964A – PIN "C" TO "4"
3968A – PIN "C" TO "8"

Figure 3-9. Direct PCA Jumper Identification

g. Set the OPERATE/CALIBRATE switch associated with the channel being calibrated to CALIBRATE.

h. Adjust the INPUT LEVEL control associated with the channel being calibrated to obtain a reading of 0 dB on the lower scale of the meter (see Figure 3-8).

i. Repeat steps c. through h. for all Direct channels in the recorder.

NOTE

It may be desirous to have a sample of the calibrating voltage on the tape before starting a recording. Perform steps j. through o. to record the calibrating voltage.

j. Check all Direct channel OPERATE-CALIBRATE switches. The switches should be set to CALIBRATE.

k. Check the SERVO switch. Should be set to the TACH position.

l. Select the desired tape speed using the SPEED controls.

m. Press the > and RECORD pushbuttons simultaneously to record in the forward mode.

n. Press the < and RECORD pushbuttons simultaneously to record in the reverse mode.

o. Press the STOP pushbutton after the period of time allotted for recording the calibrating voltage.

p. Connect Input and Output signal cables to recorder connectors and set all Direct channel OPERATE-CALIBRATE switches to OPERATE.

q. Repeat steps k., l. and m. or n. to make the recording.

3-25. DIRECT REPRODUCE OPERATION.

NOTE

Perform the record functions listed in paragraph 3-24 before performing the following procedures.

3-26. To operate the DIRECT reproduce amplifier proceed as follows:

a. Press the METERED CHANNEL SELECTOR switch associated with the channel to be operated.

b. Set the MONITOR controls for OUTPUT.

c. Set the meter selector switch to PK-AC.

d. Set the front panel SERVO switch to TACH position.

e. Select the desired tape speed using the front panel SPEED controls.

f. Press the > pushbutton only to play back in the forward mode.

g. Press the < pushbutton only to play back in the reverse mode.

h. Adjust the OUTPUT LEVEL control associated with the channel being operated for the desired output.

NOTE

A 0 dB indication on the meter scale (see Figure 3-8) indicates a 2.5V peak output. Setting the meter needle on the red triangle on the lower scale provides a 1V rms (1.414V peak) sinewave output.

i. Press the STOP pushbutton.

j. Repeat steps a. through h. for each Direct channel in the recorder.

k. Ensure that all FM channels are ready for operation using the procedures in paragraphs 3-16 and 3-18.

l. Select steps f. or g. to play back all Direct recordings.

3-27. VOICE OPERATION.

3-28. Voice operations are conducted using tape track 8 in the 3968A and tape track 4 in the 3964A. Three types of voice operation can be conducted: without a data PCA installed in channel 8 (3968A) or channel 4 (3964A); with a Direct PCA installed in channel 8 (3968A) or channel 4 (3964A); or with a FM PCA installed in channel 8 or channel 4 as applicable. In each configuration the voice record and reproduce procedures are the same. In effect, the voice and data are shared on this last channel; the data being interrupted by voice anytime the microphone press-to-talk switch is actuated.

3-29. VOICE RECORD OPERATION.

3-30. Voice recordings are made as follows:

a. Install a microphone in the MICROPHONE jack on the recorder front panel.

b. Check that the TACH-TAPE switch is set to TACH.

c. Select desired tape speed using front panel SPEED control.

d. To record in a forward mode, press the > (forward) and RECORD pushbuttons simultaneously.

e. To record in a reverse mode, press the < (reverse) and RECORD pushbuttons simultaneously.

f. Press the microphone push-to-talk button to record voice. Data may be recorded on channel 8 (3968A) or channel 4(3964A) anytime the push-to-talk button is not depressed, assuming a data channel is installed in this last channel.

3-31. VOICE REPRODUCE OPERATION.

NOTE

The voice channel (channel 8 for 3968A or channel 4 for 3964A) can be used for audible reproduction of voice or direct data. Of course, the voice channel has limited frequency response so very low or high frequency signals may not be audible. With an FM PCA installed in this last channel the FM carrier is audible at lower tape speeds signifying the presence of FM data.

3-32. Voice reproduction (playback) is conducted as follows:

NOTE

Playback can be made using the front panel speaker, or headphones. If headphones are installed in the HEADPHONE jack, the speaker output is inhibited.

a. Install headphones in the HEADPHONE jack if desired.

b. Check that the TACH-TAPE switch is in TACH.

c. Select the desired playback speed using the front panel SPEED controls.

d. Select the same mode used during the record cycle (forward or reverse record) using the MODE control.

e. Adjust the front panel VOLUME control for satisfactory hearing level.

3-33. FM FLUTTER COMPENSATION.

3-34. When FM operations are conducted in an environment where vibrations occur, such as in an aircraft, car or ship, the effects of vibration flutter can be minimized through the use of flutter compensation. This function is accomplished by inverting the FM carrier output from one FM Record/Reproduce PCA, and feeding it into the output circuits of the remaining PCA's. The feedback subtracts from the data outputs to minimize flutter effects. To conduct a flutter compensation operation proceed as follows:

a. If an FM Data is not installed in channel 5 (3968A) or channel 2 (3964A) remove the front panel (see Detail A, Figure 3-4).

b. Install a FM Data PCA in channel 5 (3968) or channel 2 (3964) (see Figure 3-7).

NOTE

A mix of FM and Direct PCA can be installed in the remaining data locations. Flutter compensation will only have effect on the other FM PCA's.

c. Set the INPUT LEVEL control on the FM PCA in channel 5 (3968) or channel 2 (3964) off (completely counterclockwise).

d. On the recorder rear panel, set the FLUTTER COMP slide switch ON (see Detail B, Figure 3-10).

NOTE

If a data input connection is made to the flutter compensating PCA (channel 5–3968; channel 2–3964) be certain the INPUT LEVEL control is completely counterclockwise. Failure to do so can route that input signal to the other data PCA's in the recorder.

e. Perform data input and output connections as necessary.

f. Set the FM and Direct levels described in paragraphs 3-13 and 3-20 as necessary.

g. Set the recorder tape speed and modes as described.

3-35. TAPE SERVO OPERATION.

3-36. Tape servo operation is used to play back with maximum accuracy of recorded data. The process involves using the same reference frequency to control the servo system during play back that was used when the recording was made. One data channel and one tape track are required for tape servo operations, which can be conducted using Direct or FM PCA's.

3-37. DIRECT TAPE SERVO OPERATION.

3-38. Tape servo operation using a Direct PCA is conducted as follows:

a. Before making the recording select a cata channel to be used to record the reference frequency. Any channel can be used for this function.

b. Connect a coaxial cable (HP Part No. 10503A) from the INTERNAL REF OUTPUT connector on the rear panel to the INPUT connector of the Direct PCA selected in step a. Figure 3-10 illustrates a connection to channel 5 in a 3968A.

c. Check position of internal-external switch on rear panel (see Figure 3-10). Should be in the internal (outward) position.

d. Install a reel of degaussed recording tape.

e. Set the recorder POWER switch ON.

f. Recorder MODE to STOP.

g. Set METERED CHANNEL SELECTOR for the selected tape servo channel. Switch to OPERATE on this channel.

h. Set the MONITOR switch to INPUT.

i. Set the meter function switch to the PK-AC position.

j. Adjust the INPUT LEVEL control on the tape servo PCA for a meter reading of +3 dB.

k. Adjust the input and output levels on all FM PCA's which are used for recording data as described in paragraphs 3-16 and 3-18.

l. Adjust the input levels on all Direct PCA's in the recorder which are used for recording data as described in paragraph 3-23.

m. Set the front panel TACH-TAPE switch to TACH.

n. Select the desired tape speed.

o. Press forward (>) RECORD. The Tape Servo reference signal will now be recorded as well as the data.

p. The recorded tape can now be reproduced in Tape Servo Mode.

q. Connect a coaxial cable (HP Part No. 10503A) between the TAPE SERVO INPUT connector on the rear panel and the OUTPUT connector of the Direct PCA selected in step a. (see Figure 3-10).

r. Rewind the tape.

s. Switch the SERVO switch to TAPE.

t. Press forward (<).

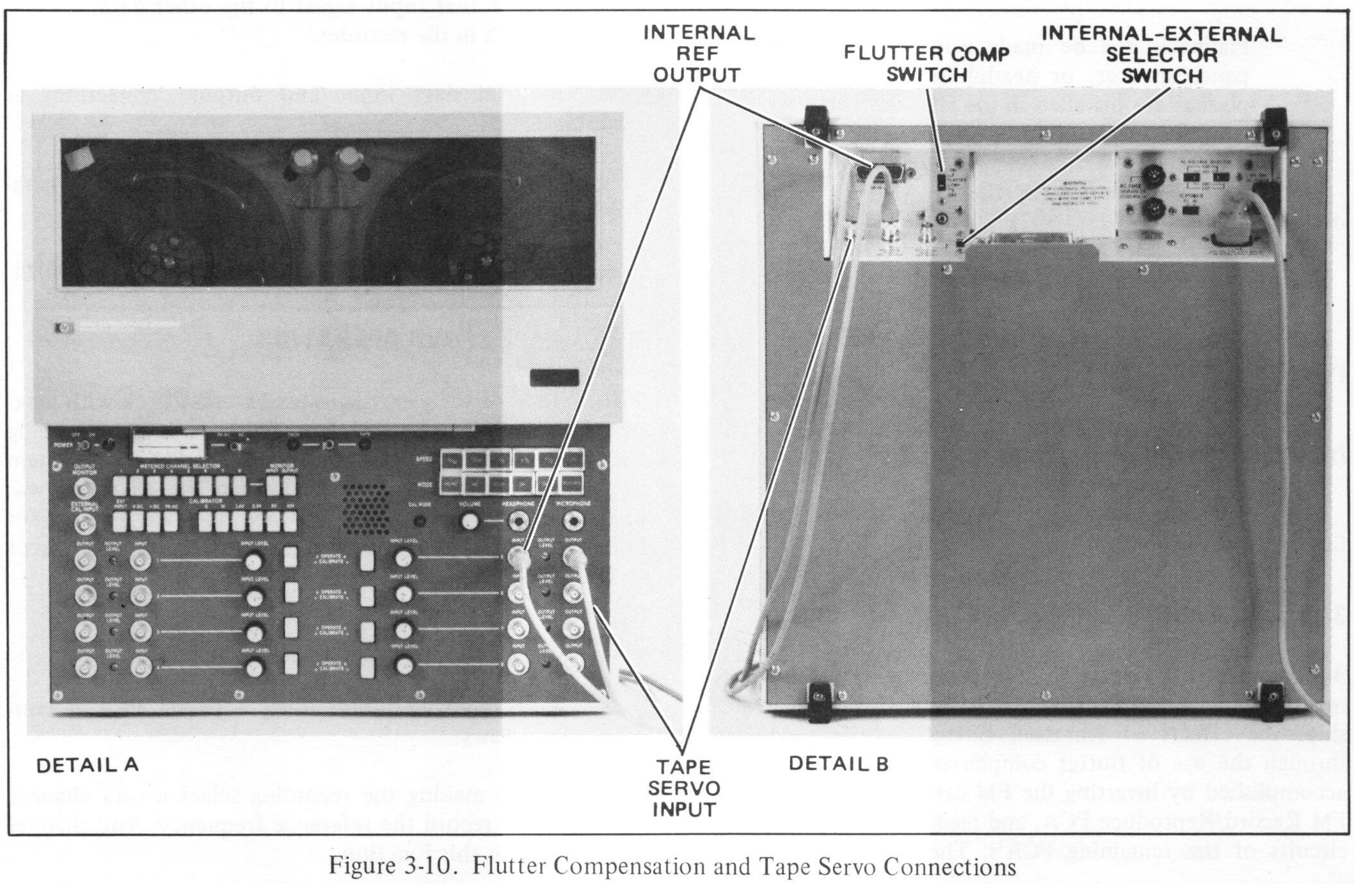


Figure 3-10. Flutter Compensation and Tape Servo Connections

u. Press MONITOR OUTPUT and adjust tape servo signal OUTPUT LEVEL to 0 dB on the PK-AC scale.

NOTE

The front panel TAPE inductor will light when the tape is moving at the selected speed.

v. Adjust the output levels on all Direct PCA's which are used for data reproduction. Use the procedures listed in paragraph 3-25.

3-39. FM TAPE SERVO OPERATION.

3-40. Tape servo operation using a FM PCA is conducted as follows:

a. Before making the recording select a data channel to be used to record the reference frequency. Any channel can be used for this function; however, combined FLUTTER COMP/TAPE SERVO operation requires that channel 5 of the 3968A or channel 2 of the 3964A be used.

b. Remove the front panel (see Detail A, Figure 3-4).

c. Remove the FM Data PCA selected to be used to record the reference frequency.

d. Make the following jumper connections on the tape servo FM Data PCA (see Figure 3-5).

DUBBING INPUT SELECTOR: Pin C to Pin D

DUBBING OUTPUT SELECTOR: Pin C to Pin D1

TAPE SERVO SELECTOR: Pin C to Pin TS

e. Reinstall the tape servo FM Data PCA and reinstall front panel. Switch to OPERATE on this channel.

f. Connect a coaxial cable (HP Part No. 10503A) from the INTERNAL REF OUTPUT connector on the rear panel to the INPUT connector of the FM PCA selected in step a. Figure 3-10 illustrates a connection to channel 5 in a 3968A.

g. Check position of internal-external switch on rear panel (see Figure 3-10). Should be in the internal (outward) position.

h. Install a reel of degaussed recording tape.

i. Set the recorder POWER switch ON.

j. Recorder is now in STOP mode.

k. Switch to OPERATE on FM channel being used for Tape Servo.

NOTE

INPUT and OUTPUT LEVEL adjustmets are not required on an FM PCA which is being used for Tape Servo.

l. Adjust the input and output levels on all FM PCA's which are used for recording data as described in paragraphs 3-16 and 3-18.

m. Adjust the input levels on all Direct PCA's in the recorder which are used for recording data as described in paragraph 3-23.

n. Set the front panel TACH-TAPE switch to TACH.

o. Select the desired tape speed.

p. Press forward (>) RECORD. The Tape Servo reference signal will not be recorded as well as the data.

q. The recorded tape can now be reproduced in Tape Servo mode. Connect a coaxial cable (HP Part No. 10503A) between the TAPE SERVO INPUT connector on the rear panel and the OUTPUT connector of the FM PCA selected in step a. (see Figure 3-10).

r. Rewind the tape.

s. Switch the SERVO switch to TAPE.

t. Press forward (<).

NOTE

The front panel TAPE indicator will light when the tape is moving at the selected speed.

u. Adjust the output levels on all Direct PCA's which are used for data reproduction. Use the procedures listed in paragraph 3-25.

3-41. COMBINED FLUTTER COMP/TAPE SERVO OPERATION

NOTE

Switching the FLUTTER COMP switch ON during combined operations disables the E-to-E function in the flutter compensation channel. This can cause noise in all FM data channel outputs when in the STOP, Fast Forward (≫), Fast Reverse (≪) and Reverse (<) RECORD modes. Switch the FLUTTER COMP switch OFF to calibrate the FM data channels, then switch ON when ready to play back.

3-42. A combined flutter compensation/tape servo operation can be performed using one data channel. This combined operation requires that a FM Data PCA be dedicated for flutter comp/tape servo use, and that the PCA be installed in channel 5 in the 3968A, or channel 2 in the 3964A. A combined operation is conducted by setting the rear panel FLUTTER COMP switch ON and performing the procedures of paragraph 3-40.

3-43. FM DUPLICATING (DUBBING) OPERATION.

NOTE

When jumpered for input or output dubbing, the metering circuits and level controls are bypassed. All meter indications should be disregarded in this mode.

3-44. FM tape duplication with the Model 3964A/3968A requires one recorder to reproduce the master tape, and one or more recorders to record the information. An illustration of a dubbing operation is shown in Figure 4-23. To set up recorders for dubbing, proceed as follows:

a. Remove the front panel on the recorder selected for reproducing the tape.

b. Remove one FM Record/Reproduce PCA.

c. Connect the Dubbing Output Selector jumper between "C" and "D2" (see Figure 3-5).

d. Replace the PCA in the recorder and set the OPERATE/CALIBRATE switch to OPERATE.

e. Repeat steps b. through d. for all FM Record/ Reproduce PCA's in the reproducing recorder.

f. Replace the front panel.

g. Remove the front panel of the recorder selected for recording.

h. Remove the first FM Data PCA for jumper positioning.

i. Connect the Dubbing Input Selector jumper between "C" and "D", and switch the INPUT LEVEL control out of the OFF position (see Figure 3-5).

j. Replace the PCA in the recorder and set the OPERATE/CALIBRATE switch to OPERATE.

k. Repeat steps h. through j. for all FM Record/ Reproduce PCA's in the recorder.

l. Replace the front panel.

m. Using coaxial cables (HP Part Number 10503A) connect the OUTPUT connectors on the reproducing instrument to the INPUT connectors on the recording instrument(s) channel 1 output to channel 1 input, etc.

n. Set both recorders POWER switch on.

o. Set the front-panel TACH-TAPE switch on both recorders to TACH.

p. Select the desired tape speed on both recorders using the SPEED controls.

q. Set the reproducing recorders MODE to > (forward).

r. Set the recording recorder MODE to > (forward) RECORD.

NOTE

Duplicating can be performed in the reverse mode. The MODE controls on each recorder are set accordingly.

3-45. DIRECT DUPLICATING (DUBBING) OPERATION.

3-46. Direct dubbing is used when tape duplication is necessary in the direct mode. To set up recorders for direct duplication, proceed as follows:

a. Using coaxial cables (HP Part Number 10503A) connect each OUTPUT connector of the Direct Record/ Reproduce PCA in the reproducing recorder to the corresponding Direct Record/Reproduce PCA in the recording instrument.

b. Set the recorders POWER switch on.

c. Set the recorders TACH-TAPE switch to TACH

NOTE

The following steps are used to calibrate the input and output levels of the Direct PCA's. Do not record during the performance of these procedures.

d. Select the desired tape speed on both recorders using the SPEED controls.

e. Set both recorders MODE to > (forward).

f. Adjust the OUTPUT LEVEL on all PCA's in the reproducing recorder using the procedures listed in paragraph 3-5.

g. Adjust the INPUT LEVEL on all PCA's in the recording instrument using the procedures listed in paragraph 3-23.

h. Set both instruments MODE control for rewind (<< fast reverse) and stop at the beginning of the tape in each instrument prior to duplication.

i. Set the reproducing recorder MODE to > (forward).

j. Set the recording instrument MODE to > (forward) and RECORD for duplication.

3-47. FM UNIPOLAR OPERATION.

3-48. To operate the Model 3964A/3968A as a unipolar, rather than bipolar device, proceed as follows for each unipolar channel:

a. Remove the front panel (see Detail A, Figure 3-4).

b. Remove the FM Record/Reproduce Amplifier PCA from the recorder.

c. For positive input signals referenced at zero, connect the Unipolar Input Selector jumper on the PCA between "C" and "–" (see Figure 3-5). If similar unipolar output is desired, connect the Unipolar Output Selector jumper between "C" and "–" (see Figure 3-5).

d. For negative input signals referenced at zero, connect the Unipolar Input Selector jumper between "C" and "+" (see Figure 3-5). If a similar unipolar output is desired, connect the Unipolar Output Selector jumper between "C" and "+".

e. Replace the PCA in the recorder. Turn POWER switch ON.

f. Set the METERED CHANNEL SELECTOR switch to the desired channel, the MONITOR switch to INPUT, and the meter function switch to DC (see Figure 3-7).

g. Set the CALIBRATOR switches to provide a DC calibration signal equal in amplitude and pllarity to the maximum input signal to be recorded.

h. Set the OPERATE/CALIBRATE switch for the desired channel to CALIBRATE.

i. If positive going signals are to be recorded, adjust the INPUT LEVEL control on the desired channel for a reading of +1. If signals are to be negative, adjust for a reading of –1.

j. Connect a DC voltmeter (HP 427A or equivalent) to the OUTPUT MONITOR connector.

NOTE

The recorder's internal meter reads 2.5V peak full scale. The output level can be adjusted for up to 5V peak-to-peak, and must be monitored externally.

k. Adjust the OUTPUT LEVEL control for the desired full scale reading (up to 5V peak-to-peak) using an external voltmeter.

l. Repeat foregoing procedures for all FM PCA's to be set for unipolar operation.

m. Set POWER switch off. Replace front panel prior to operation.

3-49. EXTERNAL SERVO REFERENCE OPERATION.

3-50. The Model 3964A/3968A is normally operated with an internally generated servo reference signal, and the servo reference switch is set to position A (see Figure 3-11).

3-51. To operate the Model 3964A/3968A with an externally generated servo reference signal, connect the external reference signal (between 1V p-p and 10V p-p) to the EXTERNAL SERVO REF INPUT connector, and set the servo reference switch to position B (see Figure 3-11). Refer to Table 3-1 for frequency requirements.

NOTE

To provide proper equalization in the Direct Data PCA's or FM carrier frequency in the FM Data PCA's, the tape speed button on the recorder corresponding to the desired tape speed must be depressed.

3-52. REMOTE CONTROL OPERATION.

3-53. Refer to Section II for remote control connections necessary for remote control operations.

3-54. HP-IB OPERATION (OPTION 007).

3-55. The HP-IB (Hewlett-Packard Interface Bus) installation in a Model 3964A/3968A Recorder includes four printed circuit assemblies (PCA's) that are installed behind the transport assembly. The assembly includes a connector and address switch that protrude through the rear panel (see Figure 3-2). When the recorder is equipped with HP-IB, both the recorder speeds and mode can be remotely controlled using a Model 9820A or 9830A Calculator through the Model 59405A HP-IB Calculator Interface. A typical HP-IB installation is shown in Figure 4-18, and

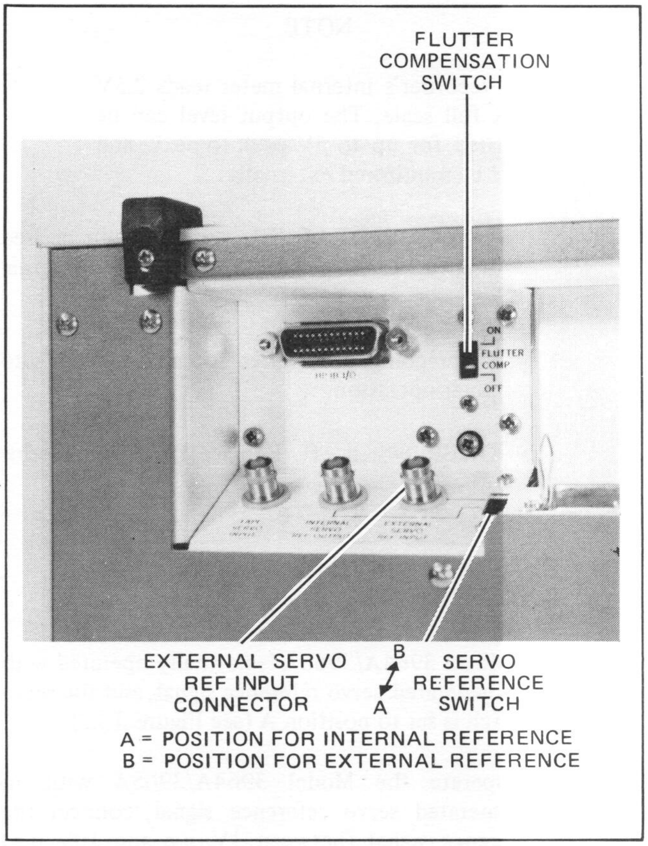


Figure 3-11. External Servo Reference Connections

wiring interconnections are shown in Figure 2-5. The following includes a detailed discussion of control functions, setting the address switch, typical program structure, and initiating delays.

3-56. CONTROL FUNCTIONS.

3-57. The recorder's speed and mode are selected by the transfer of an ASCII character from controller (calculator) to the recorder. A summation of these control words is listed in Table 3-2.

3-58. ADDRESS SELECTION.

3-59. The listen address of the interface leaves the factory preset to ASCII character "1" (00,110,001) and can be changed to any of the following codes by means of a bit selector switch on the rear panel of the Model 3964A/3968A. Instrument selection is accomplished by using the first 5 bits. Bits 6 and 7 are used to set the recorder for a listen or talk function. Various 5-bit listen addresses are listed in Table 3-3.

3-60. TYPICAL PROGRAM STRUCTURE.

3-61. The recorder can be operated by programs from both the Model 9830A and 9820A Calculators. A typical programming command from the Model 9830A Calculator follows:

Program
Line #
310 CMD "?U1", "G"

Unlisten command
Calculator talk address
Tape control listen address
Command (play forward) being sent to tape.

3-62. A typical programming command from the 9820A would be identical appearance except the term CMD would be obtained by pressing the bus command key (using PCII ROM) rather than by typing the characters C, M, D in separately.

3-63. INITIATING DELAYS.

3-64. The tape control has a built-in delay which can be activated by sending the command "O" [code 01,001,111] to an addressed listener. This delays the interface (listener's) ability to accept the next character by approximately one second, unless the controller is sending addresses following this character. For example:

```
10  CMD"?U1","GO"
20  CMD"?U3","C"
30  STOP
```

will execute line 20 immediately after line 10, while:

```
10  CMD"?U1","GON"
20  CMD"?U3","C"
30  STOP
```

will execute line 20 approximately 1 sec after line 10.

3-65. This function is generally used as required to allow the tape to respond to the desired command. For example, the tape takes about 2 seconds to reach a tape speed of 15 in./sec and thus the command 10 CMD"?U1", "6EONON" is recommended to provide enough delay for this to have happened prior to the execution of the next line. However, this is not necessary in every case, as long as the program can be doing some other, non-tape-related operation during the starting time. "Wait" statements in the 9830A such as "Wait 2000" or count loops in either the 9820A or 9830A can also be used for this purpose.

Table 3-1. External Servo Reference Frequency Requirements

Desired Tape Speed { ips	15/32	15/16	1-7/8	3-3/4	7-1/2	15
cm/sec	1.19	2.38	4.75	9.52	19.05	38.10
Required Standard Reference Input (kHz)	1.6875*	1.6875	3.3750	6.7500	13.500	27.00
Required IRIG Reference Input (Option 041) (kHz)	1.5625*	1.5625	3.1250	6.2500	12.500	25.00

*Speed reduction is accomplished internally.

Table 3-2. HB-IB Control Functions

ASCII CHARACTER	DIO BITS 8	7	6	5	4	3	2	1	DECODED CONTROL
"A"	0	1,	0	0	0,	0	0	1	Speed to 15/32 ips
"B"	0	1,	0	0	0,	0	1	0	Speed to 7-1/2 ips
"C"	0	1,	0	0	0,	0	1	1	Speed to 1-7/8 ips
"D"	0	1,	0	0	0,	1	0	0	Speed to 3-3/4 ips
"E"	0	1,	0	0	0,	1	0	1	Speed to 15 ips
"F"	0	1,	0	0	0,	1	1	0	Tape Control to "Record Forward"
"G"	0	1,	0	0	0,	1	1	1	Tape Control to "Play Forward"
"H"	0	1,	0	0	1,	0	0	0	Speed to 15/16 ips
"I"	0	1,	0	0	1,	0	0	1	Tape Control to "Fast Forward"
"J"	0	1,	0	0	1,	0	1	0	Tape Control to "Fase Reverse"
"K"	0	1,	0	0	1,	0	1	1	Tape Control to "Stop"
"L"	0	1,	0	0	1,	1	0	0	Tape Control to "Play Reverse"
"M"	0	1,	0	0	1,	1	0	1	Tape Control to "Record Reverse"

Table 3-3. Address Selection

NOTE

The character "?" is the unlisten command, and should not be selected by the selector switch (switch pattern 1 1 1 1 1) even though it is possible to do so.

ASCII CHARACTER	TALK-LISTEN SELECTION			ADDRESS SELECTION				
	8	7	6	5	4	3	2	1
1	0	1,	1	1	0,	0	0	1
2	0	1,	1	1	0,	0	1	0
3	0	1,	1	1	0,	0	1	1
4	0	1,	1	1	0,	1	0	0
5	0	1,	1	1	0,	1	0	1
6	0	1,	1	1	0,	1	1	0
7	0	1,	1	1	0,	1	1	1
8	0	1,	1	1	1,	0	0	0
9	0	1,	1	1	1,	0	0	1
:	0	1,	1	1	1,	0	1	0
;	0	1,	1	1	1,	0	1	1
<	0	1,	1	1	1,	1	0	0
=	0	1,	1	1	1,	1	0	1
>	0	1,	1	1	1,	1	1	0

3-66. CONDUCTING A SERIAL POLL.

3-67. The recorder is also capable of initiating or being involved in a serial poll when the machine is out of tape. When the recorder runs out of tape, it generates a request service. This can be checked on the Model 9830A Calculator by the statement <variable> – stat 13. If <variable> = 0 or 1, some device has requested service. One procedure for conducting a serial poll on the 9830A Calculator is as follows:

```
910  CMD"?U"
920  FORMAT 3B
930  OUTPUT (13,920) 256,24,512;
940  CMD"Q5"
950  A = RBYTE13
960  IF A = 96 then 980
970  60 to 1000
980  DISP "LOAD TAPE"
990  STOP
1000 OUTPUT (13,1010) 256,25,512;
1010 FORMAT 3B
```

3-68. Line 930 outputs the serial poll enable (having a decimal equivalent of 24). Line 940 addresses the recorder as a talker and the calculator as a listener. Line 950 inputs a character (the status byte) from the recorder. If this character is 96 the recorder requested service and is out of tape. If this character is 0, the recorder did not request service, therefore some other instrument on the bus did. This instrument is discovered as each instrument capable of requesting service on the bus is addressed in turn. Line 1000 terminates the serial poll by sending the character with a decimal equivalent of 25 (serial poll disable).

3-69. In the Model 9820A Calculator, this function varies slightly using the statement: Rds 13 → <variable>. If <variable> or 1 = 0 then some device has requested service. A typical procedure for conducting the poll is as follows:

26:CMD "? 5 "

SERIAL poll enable (use record key for 9820A Diamond key for 9821A)

27:CMD"Q"

28:RDB 13 A

29:IF A = 0:6+032

30:IF A = 96:DSP

"LOAD TAPE"

31:STOP

32:CMD"? "

Serial poll disable command (use jump key)

3-70. Line 26 places the interface in the serial poll mode. Line 27 sends the recorder talk address. Line 28 outputs the status byte to the calculator. Lines 29 and 30 examine the character to see if the tape recorder being addressed has run out of tape or not. Additional lines then output status bytes from other devices and finally (Line 32) the serial poll mode is disabled. In either case addressing the tape as a talker while not in the serial poll mode results in zeros being transmitted regardless of tape condition.

3-71. TAPE LOOP ADAPTER OPERATION (OPTION 024).

3-72. TAPE LOADING.

3-73. To load the adapter with tape, proceed as follows:

a. Remove transparent cover from bin assembly by grasping its edges and lifting straight up.

b. Place a reel of tape on the left shaft (over the supply hub) and unwind about two feet of tape, routing the tape over the tape rollers to the bin entrance (see Figure 3-12).

c. Press the left end of the roller assembly arm toward the turntable to move the roller away from the turntable rim.

d. Place tape between the turntable rim and the roller. Release the roller assembly arm, allowing the roller to press the tape against the rim of the turntable.

e. Route the tape around the inside rim of the storage bin.

f. Feed the tape past the exit guide. Push the tension block against the spring, place the tape between the tension block and the exit guide, and release the tension block.

g. Bring the tape from the exit guide out around the supply idler along the path shown in Figure 3-12.

h. Place transparent cover over bin assembly by pressing it straight down.

i. Set the Reel Revolution Counter to zero, using the Reset button.

j. Pack the required amount of tape into the bin by rotating the turntable clockwise by hand. The counter will read one foot per revolution. Cut the tape and remove the tape reel.

k. Splice the tape, making sure that the splicing tape is on the mylar (back) side of the tape, so that it will not pass over the head surfaces.

l. Feed the tape from the supply idler over the top of the right hand pin of the crossover arm, under the two middle pins, and over the top of the left hand pin.

m. Pass the tape around the supply hub and behind the two tape rollers.

n. Place a pencil vertically behind the tape between the two tape rollers and gently draw a loop of tape straight toward you.

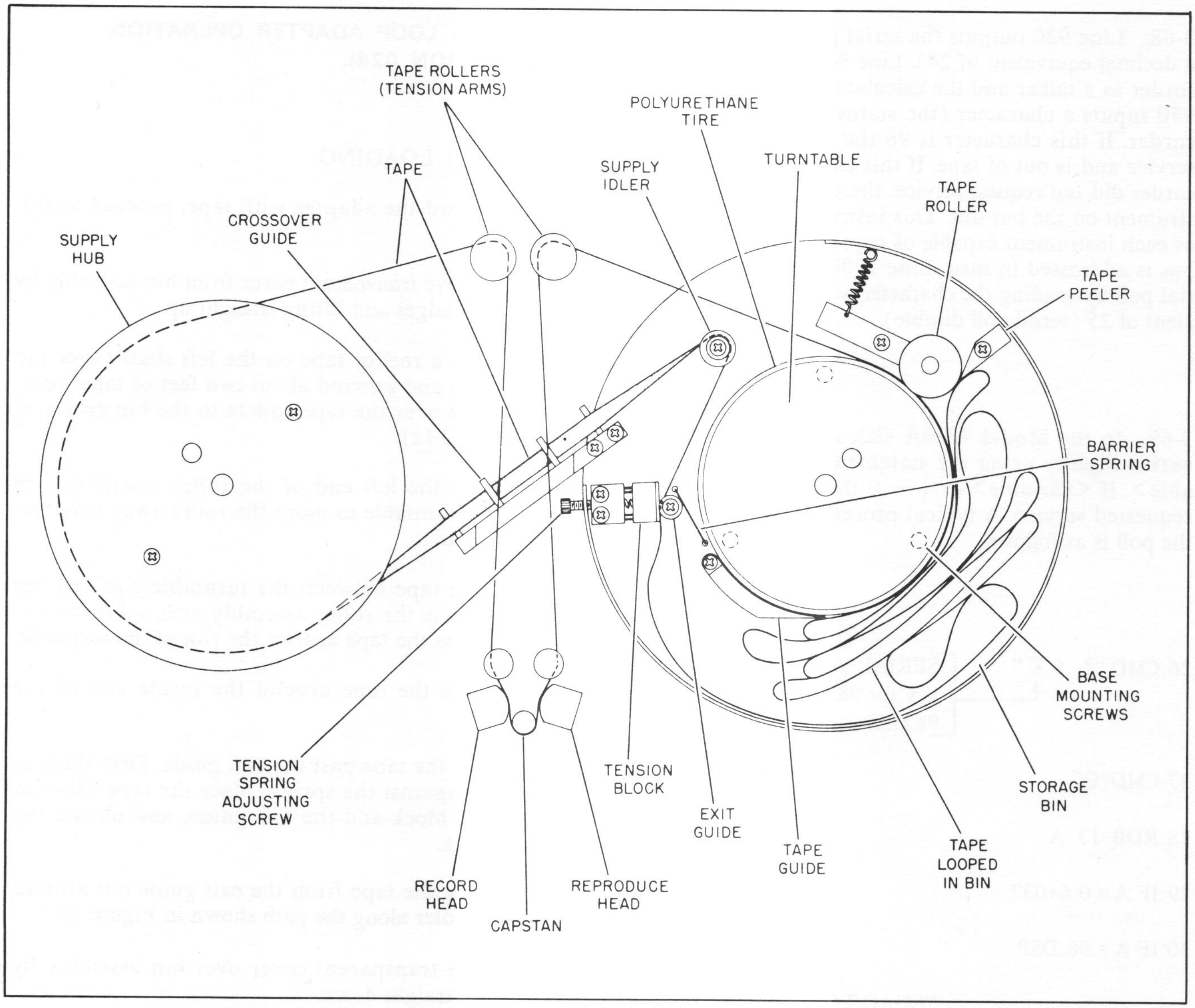


Figure 3-12. Tape Loop Adapter Nomenclature and Tape Path

o. Place the loop of tape around the outside of the tape guides and the capstan. Position the tape over the record and reproduce heads (maneuvering the tape with a pencil if necessary) and make sure the tape is properly seated in the grooves in the tape guides.

p. Pressing lightly with the fingertips on the cover of the bin assembly, rotate the turntable clockwise to take up the slack in the tape loop.

3-74. RELOADING A TAPE LOOP.

3-75. The process of loading the Adapter with a previously spliced loop of tape is essentially the same as the process just described, except that the packing may be speeded up by using the tape transport rather than winding the turntable by hand. To reinstall an already spliced loop of tape, proceed as follows:

a. Find the splice in the tape loop; then follow steps c. and d. of paragraph 3-73, making sure the splicing tape is on the side of the tape away from the turntable.

b. Follow steps e. through h. of paragraph 3-73.

c. Turn on the recorder.

d. Select 15/32 ips speed.

e. Pass the tape from the bin entrance behind the two tape rollers.

f. With your right hand, press the tape rollers toward you to close the tension interlock.

g. Holding the tape in your left hand to feed it smoothly to the tape rollers, press > (forward). The turntable will rotate and feed the tape randomly into the storage bin. Continuous light fingertip pressure on

the tape rollers is necessary to keep the interlock closed.

h. When nearly all the tape is packed in the bin, press the STOP switch.

i. Complete the threading process by performing steps n. through p. of paragraph 3-73.

3-76. RECORDER OPERATION WITH A TAPE LOOP ADAPTER.

3-77. To operate the recorder with the Tape Loop Adapter installed, and the tape loaded as indicated in paragraph 3-73, proceed as follows:

a. Connect the recorder to a suitable power source.

b. Turn on the recorder.

c. Select 15/32 ips speed.

d. Press > (forward).

e. Check to see that tape is tracking properly.

NOTE

If tape does not track properly, perform adjustment procedures described in paragraph 3-78 and 3-79.

f. Press STOP switch to stop transport.

3-78. TAPE GUIDE AND TAPE PEELER ADJUSTMENTS.

3-79. With the recorder in the STOP mode (and with no tape threaded), perform the following steps:

a. Loosen the screw at the left end of the guide (see Figure 3-11) and position the right end of the guide approximately .006 inch from the rim of the turntable; tighten the screw.

b. Loosen the peeler mounting screw (see Figure 3-12) and position the peeler tip approximately .010 inch from the roller; tighten the screw.

NOTE

Recording tape may be used as a feeler gauge. Six layers = .006″, ten layers = .010″.

3-80. CROSSOVER ARM ADJUSTMENTS.

3-81. With tape threaded, the TAPE SPEED selector switch set at the 3-3/4 ips, and the recorder in the > (forward) mode, proceed as follows:

a. Loosen the two screws holding the crossover arm to the base of the bin assembly (see Figure 3-12). Between these two screws, under the crossover arm, is a "rocker" (rivet). Loosening one screw a small amount and tightening the other a similar amount will move the left end of the crossover arm in a vertical plane.

b. Adjust these two screws until the tape leaving the crossover arm enters the left hub centrally, i.e., neither top nor bottom hub flange rubs the tape.

NOTE

With this adjustment completed, the screws should be snug, but **not** tightened excessively.

3-82. SUPPLY TENSION ADJUSTMENT.

3-83. With tape threaded, 3-3/4 ips speed selected and the recorder in the > (forward) mode, proceed as follows:

a. Back off the tension adjusting screw to the tension block (see Figure 3-12) until the left hub stops or turns backwards due to loss of tension.

NOTE

The optimum adjustment will vary with temperature and humidity due in part to recording tape characteristics. Thus, even while operating within the specified range of temperatures and/or humidity, adjustments should be made to optimize the performance for the specified actual environment.

b. Turn the adjusting screw in until the correct tension is achieved.

NOTE

Increasing the tension will pull the left tension arm down from its normal at-rest position at the top of its slot. When the tape is at the correct tension, the left tension arm will be pulled approximately one-third of the way down the slot, and the supply hub will be driven forward (clockwise).

3-84. OVERLAP OPERATION (OPTION 070).

3-85. To operate the Model 3964A/3968A overlap option, proceed as follows:

a. Assign a sequence number to each recorder, i.e., 1 operates first, followed by 2, 3, etc.

b. Connect $\overline{\text{OVERLAP FORWARD COMMAND}}$ pin 5 on remote control connector A24J2 in recorder 1 to $\overline{\text{FORWARD}}$ pin 22 on remote control connector A24J2 in recorder 2 (see Figure 2-4 for remote connector pin locations).

c. Connect $\overline{\text{OVERLAP RECORD COMMAND}}$ pin 4 on remote control connector A24J2 of recorder 1 to $\overline{\text{RECORD}}$ pin 49 on remote control connector A24J2 of recorder 2 (see Figure 2-4).

d. Repeat steps b. and c. for additional recorders as necessary.

NOTE

If continuous operation is desired and recorder 1 has been reloaded with tape, perform step e. to connect the last recorder in a chain back to recorder 1.

e. Connect $\overline{\text{OVERLAP FORWARD COMMAND}}$ pin 5 and $\overline{\text{OVERLAP RECORD COMMAND}}$ pin 4 on the last recorder to $\overline{\text{FORWARD}}$ pin 22 and $\overline{\text{RECORD}}$ pin 49 in recorder 1.

f. Install BNC "T" connectors on the INPUT connectors on each data PCA in each recorder in the overlap chain.

g. Connect the data sources to one side of INPUT "T" connectors on each data PCA to be used in recorder 1.

h. Connect other side of INPUT "T" connector on each data PCA in recorder 1 to one side of INPUT "T" connector on the associated data PCA in recorder 2; i.e. channel 1 to channel 1, channel 2 to channel 2, etc.

i. Connect other side of INPUT "T" connectors on recorder 2 to one side of INPUT "T" connectors on recorder 3.

j. Repeat steps h. and i. for each recorder in the chain. The last recorder does not require data termination.

NOTE

All recorders to be used in an overlap sequence should have identical FM or Direct electronics installed.

k. Adjust INPUT level controls on all Record/Reproduce PCA's (see paragraph 3-16 or 3-23 as applicable).

l. Set the OVERLAP switch to REWIND, STOP, or OFF as desired (see Figure 3-13).

NOTE

If REWIND is selected, the right tape reel is emptied. If OFF is selected, the left tape reel is emptied. If STOP is selected, the left tape reel is depleted but not completely emptied.

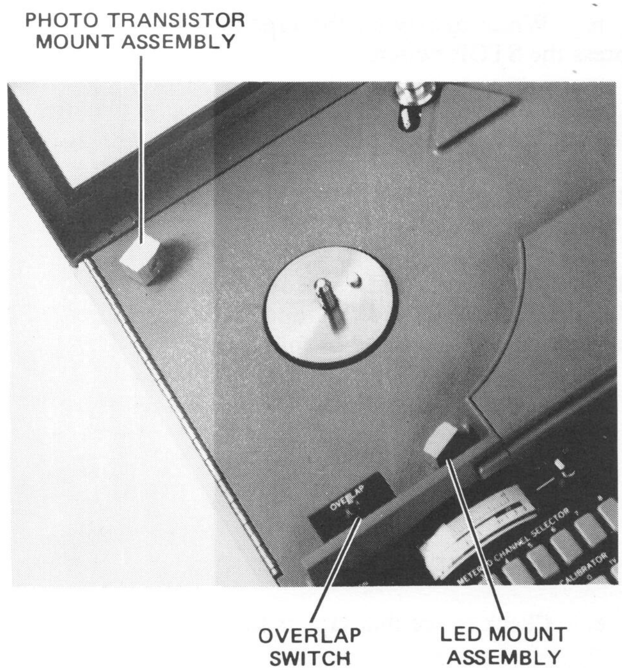


Figure 3-13. Overlap Control Location

m. To start the recording sequence, press the > (forward) and RECORD buttons.

3-86. METER OPERATION.

3-87. The front panel meter contains two scales to be used in the operation of the recorder. The lower scale is calibrated in dB, and can be used with both AC and DC input data. When using the lower scale, the front panel PK-AC/DC switch is set to PK-AC. The upper scale on the meter is uncalibrated, but provides approximate level indications and polarities of input DC signals. The PK-AC/DC switch is set to the DC position when using this scale. Procedures for using the meter for monitoring on calibration procedures are described in the following paragraphs. See Figure 3-14 for control identification.

3-88. RECORD MONITORING.

3-89. To monitor a record signal proceed as follows:

a. Connect the desired data channel to meter using the METERED CHANNEL SELECTOR pushbutton.

b. Connect the record section of the data channel to the meter by setting the MONITOR INPUT pushbutton.

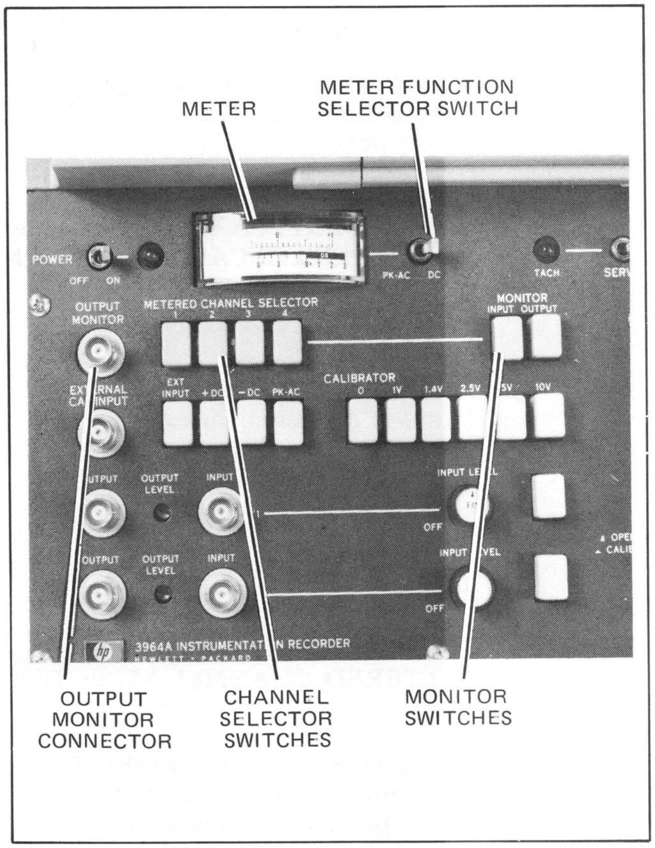


Figure 3-14. Metering Controls

c. When using FM electronics with DC input signals, the PK-AC/DC switch can be set to DC. (PK-AC can also be used.)

d. If the meter is set to DC adjust the data PCA INPUT LEVEL control for an upper-scale reading of +1 or -1, as applicable for input signal polarity.

NOTE

To verify correct setting of INPUT LEVEL control, set PK-AC/DC switch to PK-AC. Meter should indicate 0 dB on lower scale. Make adjustment of INPUT LEVEL control for correct reading if necessary.

e. When using Direct Electronics, set PK-AC/DC switch to PK-AC. Adjust INPUT LEVEL control for meter indication of 0 dB on lower scale.

3-90. REPRODUCE MONITORING.

3-91. To monitor a reproduce signal proceed as follows:

a. Connect the desired data channel to meter using the METERED CHANNEL SELECTOR pushbutton.

b. Connect the reproduce section of the data channel to the meter by setting the MONITOR OUTPUT pushbutton.

c. When using FM or Direct Electronics, the PK-AC/DC switch can be set to PK-AC.

d. If the meter is in PK-AC mode adjust associated OUTPUT LEVEL control for a 0 dB reading on lower scale of meter. This meter reading indicates an output level of 2.5V PK from the reproduce electronics.

NOTE

If the polarity of an output FM signal is not known, the PK-AC/DC switch can be set to DC after performing step d. The meter will then indicate output signal polarity. (A meter reading of +1 is equivalent to +2.5V PK and -1 is equivalent to -2.5V PK.)

NOTE

A small red triangle is located near the 6 dB mark on the lower scale of the meter. This mark is used when monitoring or calibrating the reproduce section. Adjusting the OUTPUT LEVEL control so that the needle rests on this triangle, provides a 1V rms signal of a sinewave from the data channel.

3-92. METER OPERATION USING THE CALIBRATOR.

3-93. The Model 3964A/3968A has internal AC and DC reference voltages available for calibration. In addition, a connector is provided to allow an external reference voltage to be used in place of the internal reference. For ease of identification, all switches associated with the calibrator are color coded light gold. To set up the calibrator, proceed as follows:

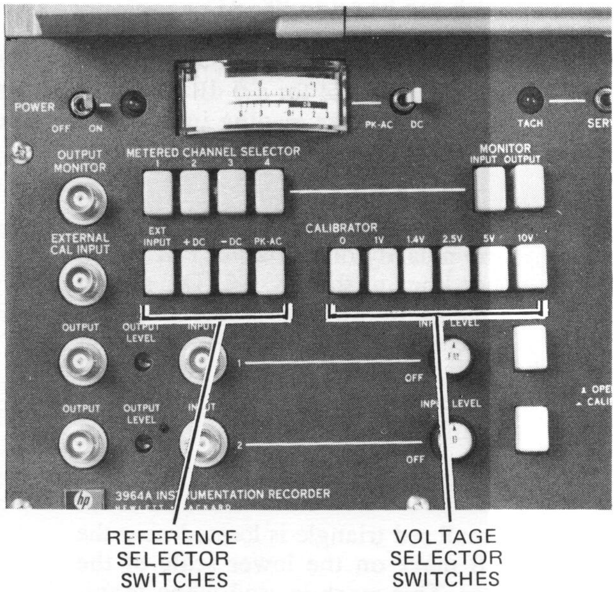
a. Select the calibrator reference using the reference selector switches (see Detail A, Figure 3-15). This can be 500 Hz AC, positive DC, negative DC, or an external reference connected to the EXTERNAL CAL INPUT connector.

NOTE

The 15/16 ips and 15/32 ips tape speeds cannot be calibrated with 500 Hz AC. Calibration at these lower speeds should be performed with a DC voltage.

b. Select the calibration voltage using the voltage selector switches. The front panel switches are used to select voltages of 0, 1, 1.4, 2.5, 5 and 10V.

DETAIL A



DETAIL B

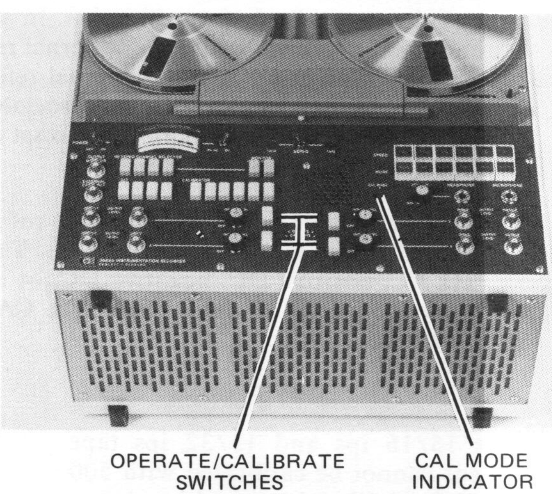


Figure 3-15. Calibrator Controls

NOTE

Using the 1.4 switch with AC selected provides an actual calibration voltage of 1.414, the peak value of a 1V rms sine wave.

c. Select the FM or Direct PCA to be calibrated by setting the associated OPERATE-CALIBRATE switch to CALIBRATE (see Detail B, Figure 3-15).

NOTE

When an OPERATE/CALIBRATE switch button is depressed, the calibrator output is connected to the data channel record input and the data signal is disconnected. In addition, the CAL MODE indicator will be on as long as any channel is in the CALIBRATE mode.

d. Connect the FM or Data PCA to meter by using the associated METERED CHANNEL SELECTOR switch.

e. To set the data PCA input level, set the MONITOR INPUT pushbutton and adjust the PCA INPUT LEVEL control using procedures in paragraph 3-16 or 3-23 as applicable.

f. To set the data PCA output level, set the MONITOR OUTPUT pushbutton and adjust the PCA OUTPUT LEVEL control using procedures in paragraph 3-18 or 3-25 as applicable.

3-94. OPERATOR MAINTENANCE.

3-95. The procedures listed in the following paragraphs are commonly performed by the operator of the recorder, and are intended to clean all transport parts that come into contact with the tape. Oxide buildup can cause degradation of high-frequency response, distorted recordings, play back and tape/head damage. These procedures are intended to maintain the instrument in optimum operating status.

3-96. HEAD, CAPSTAN AND TAPE GUIDE CLEANING PROCEDURE.

3-97. To clean the heads and tape handling system, proceed as follows:

a. Turn POWER switch OFF.

b. Open reel and head covers.

c. Remove interhead shield from recorder (see Detail A, Figure 3-16).

d. Remove tape from recorder.

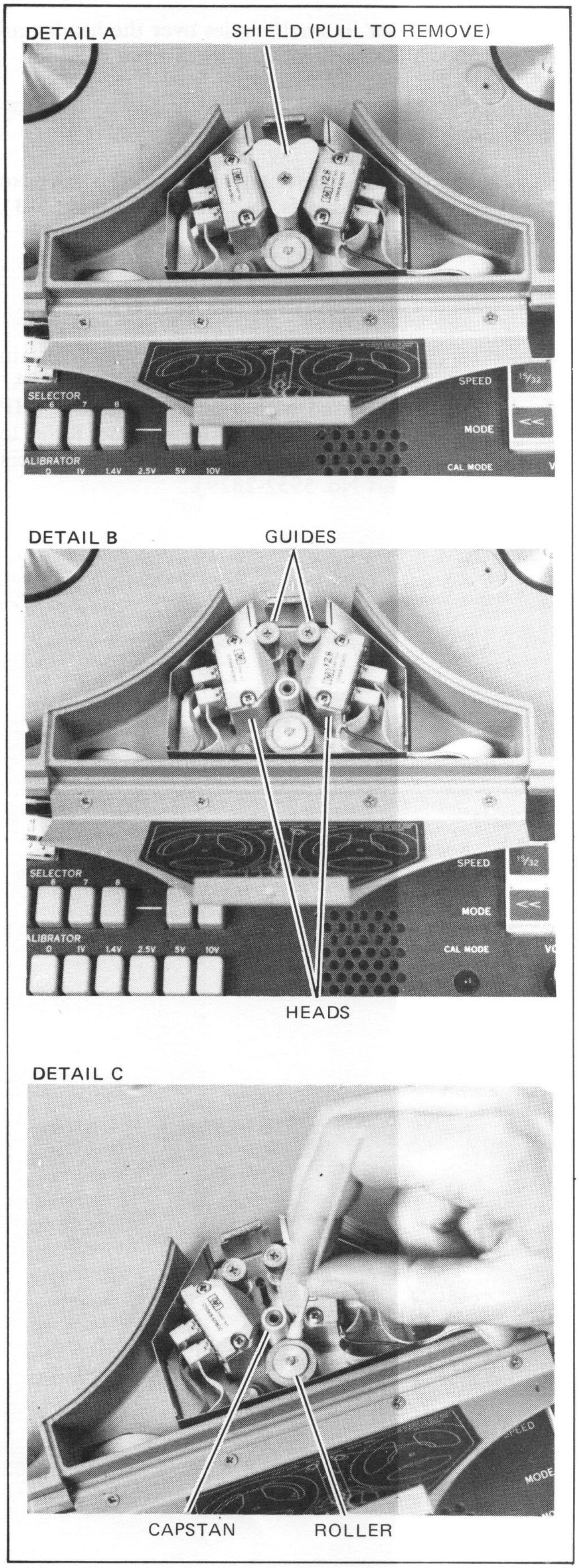


Figure 3-16. Head, Capstan and Guide Cleaning

CAUTION

Do not use toluene or xylene cleaning agents on the pinchroller and do not allow cleaning agents to come into contact with the magnetic tape. Use cleaning agent sparingly and keep it out of the bearings at the base of the capstan.

e. Using a cotton swab wet with head cleaner HP Part Number 8500-1251, (both items furnished in Accessory Kit), remove all dirt and tape residue from tape guides (see Detail B, Figure 3-16) and tension arms (see Figure 3-1).

NOTE

If the deposits on the heads, capstan and pinchroller are particularly heavy, Isopropyl Alcohol (91% high purity such as HP Part No. 8500-0559) may be used as an alternate cleaner.

f. Using a cotton swab wet with head cleaner to remove all dirt and residue from the tape heads.

g. Turn POWER switch ON.

h. Manually move the tension arms toward the heads until STOP button light comes on. Retain arms in this position.

NOTE

With the tape reels removed, performance of step i. causes the reel hubs to rotate rapidly. No damage to the reel motor circuits will occur as a result of this rapid movement.

i. Depress > (forward) button.

j. Using a cotton swab wet with head cleaner, clean the capstan and pinchroller (see Detail C, Figure 3-16).

k. If the recorder is equipped with a Tape Loop Adapter (Option 024), the adapter should be cleaned with Freon TF (DuPont).

l. Release tension arms. Turn POWER switch OFF.

m. Proceed to paragraph 3-98 to degauss the heads and tape guides.

3-98. HEAD AND TAPE GUIDE DEGAUSSING.

3-99. To degauss the heads and tape guides, proceed as follows:

CAUTION

Insure that recorder is switched OFF before degaussing.

a. Refer to paragraph 3-97. Perform steps a. through d.

NOTE

Always turn the bulk tape eraser on or off out of degaussing range of the recorder. This is necessary to prevent inadvertent magnetization of recorder metal parts or recording tape.

b. Turn bulk tape eraser on.

c. Place bulk tape eraser next to heads.

d. Move eraser in small circles over the heads and tape guides while slowly moving away from recorder.

e. When eraser is at least three feet away from recorder, turn eraser off.

f. Degauss the interhead shield and return to proper place between heads (see Detail A, Figure 3-3).

g. Replace tape head cover and reel cover.

3-100. TAPE DEGAUSSING (ERASING).

3-101. The HP Model 3964A/3968A does not contain an erase head. All tape used with the Model 3964A/3968A should be erased with a bulk tape eraser (HP Model 13064A Tape Degausser) prior to use. Refer to the erasure procedures in the HP Technical Data Sheet of April 1976 (Part No. 5952-2829).

SECTION IV

THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. This section contains the principles of operation for both the Model 3964A and Model 3968A Instrumentation Tape Recorders. Included herein is a general description of the recorders' mechanical and electronic assemblies, and detailed descriptions of the electronic circuits. The general descriptions use simplified block diagrams, which are included in this section. The detailed circuit descriptions are referenced to servicing block diagrams and schematic diagrams located in Section VII of the manual.

4-3. GENERAL DESCRIPTION.

4-4. The Model 3964A Recorder is a four-channel, six-speed instrumentation device, and the Model 3968A is an eight-channel recorder. Both recorders use 1/4-inch magnetic tape and are capable of FM recording and reproducing over a bandwidth from DC to 5 kHz, or direct recording and reproducing over a frequency range between 100 Hz to 64 kHz. A mix of both type data recording electronics can be installed in each instrument. This general description includes a discussion of logic symbology used in the manual, a description of transport assembly units and electronic assemblies, and operational information on the following functional recorder circuits: mode control, speed control, servo system, FM data electronics, direct data electronics, voice electronics, recorder power sources, overlap electronics (Option 070); and HP-IB electronics (Option 007).

4-5. LOGIC SYMBOLOGY.

4-6. To simplify circuit analysis, the logic symbols in this manual are illustrated using functional notation rather than actual pack layout when appropriate. As an example, a two-input NAND gate may be performing an OR function, and is illustrated as a low-input OR gate as shown in Figure 4-1. Illustrations of functional and pack gate symbology with associated truth tables are shown in Figure 7-1 at the rear of this manual.

4-7. Inverter dots are used to indicate a low at a device, and a bar over a signal name denotes that this signal is low when active. Non-inverted lines at any device and unbarred signal names are assumed to be high when active. All logic on the printed circuit assemblies (PCA's) in the recorder is TTL, positive true (1 = true = +2.4 Vdc to +5 Vdc; 0 = false = 0 Vdc to 0.4 Vdc). Any remote control or HP-IB interfacing levels between controller and recorder are TTL, negative true (1 = true = 0 Vdc to 0.4 Vdc; 0 = false = 2.4 Vdc to +5 Vdc). Levels between the HP-IB controller and the recorder have an "L" or "H" suffix to this signal as an indicator rather than the barred or unbarred signal names.

4-8. TRANSPORT ASSEMBLY.

4-9. The transport assembly is electromechanical in construction and contains the record and reproduce heads, capstan motor, pinchroller, tape guides, reel motors, damper assemblies, end-of-tape (EOT) sensing microswitches, overlap sensing electronics and selector switch, and a mechanical counter with reset that indicates number of reel revolutions. The following discussion describes the transport assemblies using Figure 4-2 for reference.

4-10. RECORD/REPRODUCE HEADS. The record and reproduce heads are 4-track or 8-track, magnetic heads for use with 1/4-inch magnetic tape. Track arrangement and track spacing dimensions are shown in Figure 4-3. During a record process, when the tape is moved across the record head, the magnetic material (oxide) on the tape is subject to a flux pattern that is proportional to the current in each track winding. When reproducing, magnetic lines of flux are passed through the reproduce head that are proportional to the magnetic pattern on the tape. This information is detected and amplified then passed to the data channel electronics for processing before playback. A detailed analysis of magnetic recording is contained in Application Note 89 "The Magnetic Tape Recording Handbook", revised October 1975. Reference is made to this document for further recording-reproduction details.

4-11. CAPSTAN, CAPSTAN MOTOR AND TACHOMETER. The capstan (see Detail A, Figure 4-2) is part of the capstan assembly and moves the tape over the record and reproduce heads. The unit is a stainless steel shaft with a ceramic sleeve that provides traction to move the tape. The capstan motor (see Detail B, Figure 4-2) is a permanent magnet, printed-circuit DC motor featuring low inductance and inertia. The armature of the motor is fastened directly to the shaft that serves as a capstan. The tachometer, which is not shown in Figure 4-2, consists of 2048-line optical disc (1890-line disc for IRIG Option 041), a light source and light-sensitive, photo-transistor. The disc is

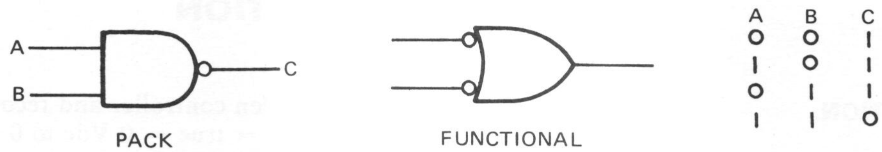


Figure 4-1. Typical Functional Logic Expression

electronically centered and permanently secured to the capstan motor shaft. As the capstan motor turns, the tachometer develops a sine wave frequency proportional to capstan motor speed. This frequency is fed into Servo Loop PCA A8, and is used to phase-lock the capstan to a reference frequency that is the product of a selected tape speed. The servo loop is discussed in further detail later in this section. The capstan motor assembly, which includes the capstan, motor and tachometer is not field repairable. If trouble occurs, the assembly should be replaced through the exchange program.

4-12. PINCHROLLER AND SOLENOID. The pinchroller (see Detail A, Figure 4-2) is a metal shaft with a free-moving roller attached that is used to hold the tape against the capstan during forward or reverse play. This arrangement ensures that the tape moves across the record/reproduce heads at the capstan rate. The pinchroller is disengaged during fast forward, fast reverse and when a stop is made. The pinchroller solenoid (see Detail B, Figure 4-2) is actuated when the recorder is in forward or reverse play by a control signal from Mode Control PCA A6.

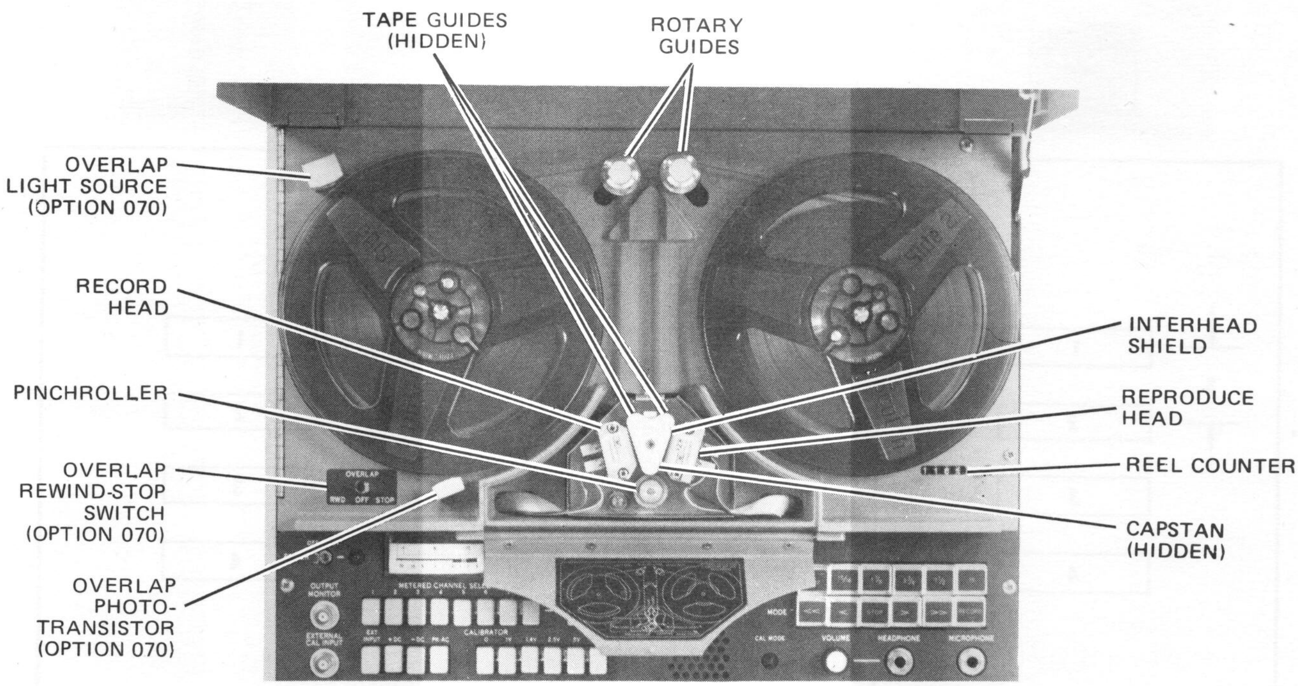
4-13. INTERHEAD SHIELD. The interhead shield (see Detail A, Figure 4-2) is constructed of a magnetic material and is used to prevent interaction between the record head and reproduce head. The shield can be removed for tape path cleaning.

4-14. TAPE GUIDES. There are two tape guides (see Detail A, Figure 4-2) beneath the interhead shields. These devices are used to guide the tape from the left damper arm over the record head and from the reproduce head over the right damper arm. Each guide is machined stainless steel with a tape-width groove to accommodate the 1/4-inch recording tape.

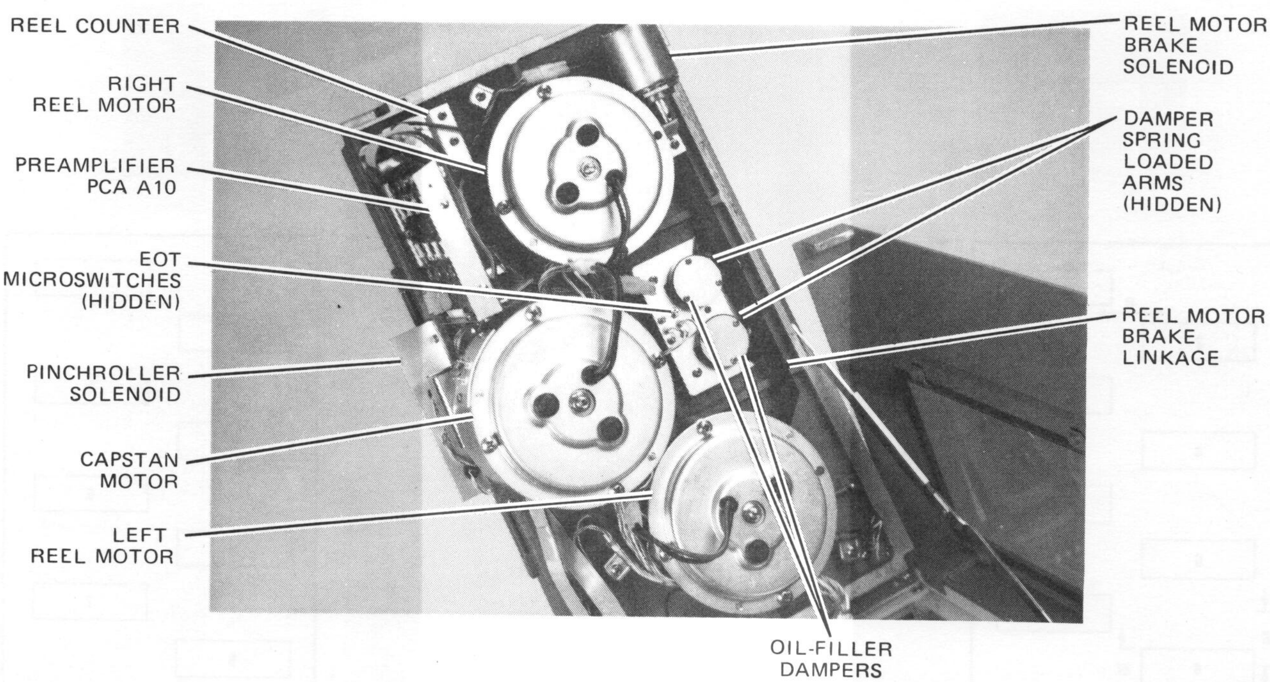
4-15. DAMPER ASSEMBLY. The damper assembly provides tape buffering to compensate for uneven tape velocity off the supply reel, thus effectively isolating the reel assemblies from critical tape path elements. The damper assembly consists of two rotary guides (see Detail A, Figure 4-2) that are connected to oil-filled dampers (see Detail B, Figure 4-2) by spring-loaded arms (see Detail B, Figure 4-2). The tape rollers of the rotary guide assembly do not guide the tape, since the rollers are barrel shaped with cut-away flanges to prevent tape-edge damage. The springs of the damper assembly are non-linear, helical devices with a variable spring rate. The springs, in conjunction with the oil-filled dampers, absorb arm action and keep tape speed constant.

4-16. Two damper arm actuated microswitches, which are located beneath the damper cover plate, (see Detail B, Figure 4-2) are connected in parallel with a control circuit on Mode Control PCA A6. When tape is loaded and tension is normal, the microswitches are closed. If tape tension is removed, as would be the case at the end of a reel or if a break occurs, the arms move to a rest (up) position. This opens the microswitches and provides an EOT (end-of-tape) signal to PCA A6. Both microswitches must be open to generate EOT. Further discussions of the EOT condition are provided later in this section.

4-17. REEL MOTORS. The two reel motors (see Detail B, Figure 4-2) are permanent-magnet, printed-circuit DC motors of the same construction as the capstan motor. The reel motor armatures are fastened directly to the shaft that carry the tape reels. The reel motors are operated by a current source on Capstan/Reel Motor Driver PCA A2 when in forward or reverse play modes through a 3-relay matrix located on Interconnect PCA A24. This current supply is under control of logic circuits on Mode Control PCA A6. In the fast forward and fast reverse modes, the reel motors control tape movement, with current flowing from the +11 Vdc power supply in the same direction through both motors. In the forward play and reverse play modes,



DETAIL A — TRANSPORT CLOSED



DETAIL B — TRANSPORT OPEN

Figure 4-2. Transport Assembly Parts Identification

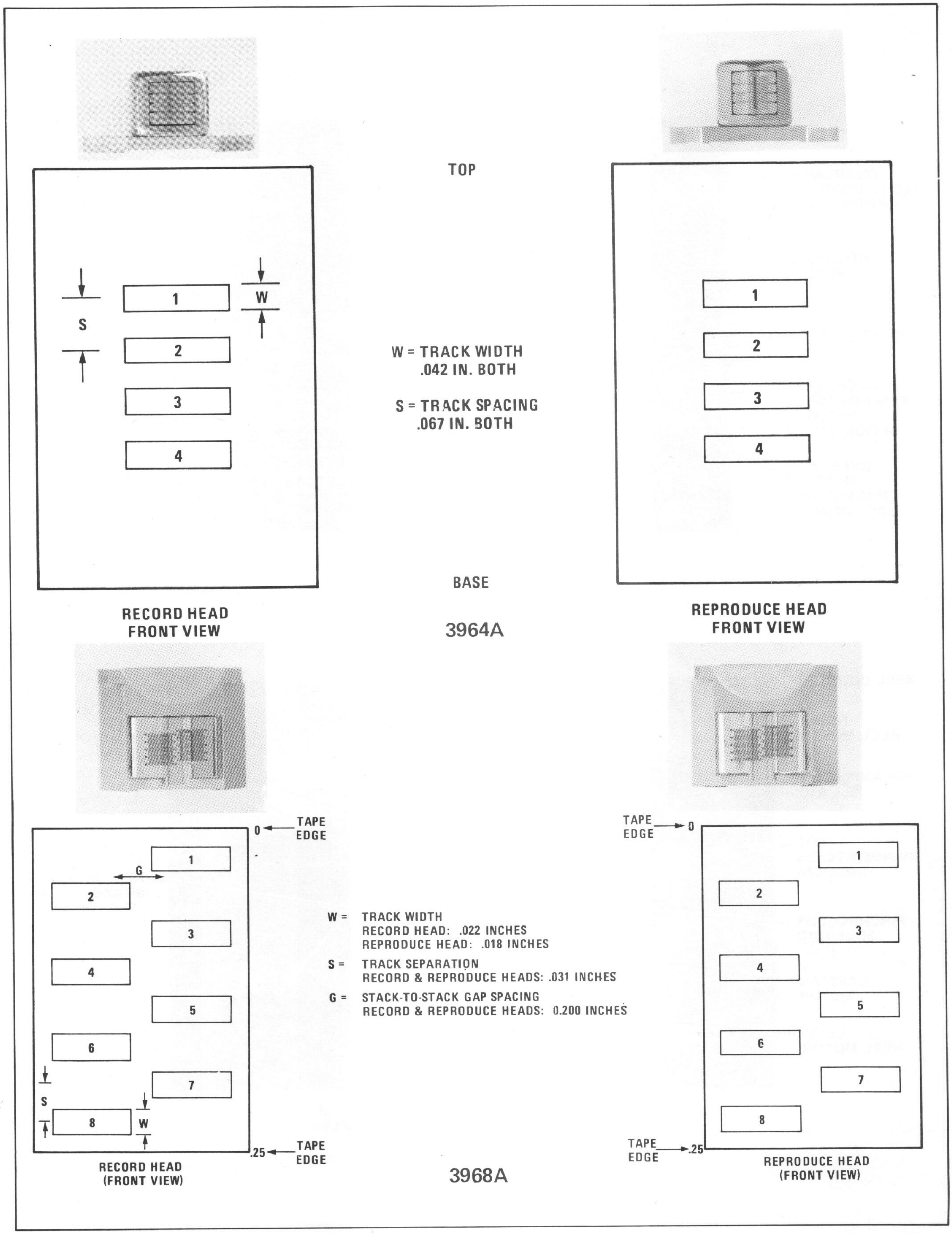


Figure 4-3. Record/Reproduce Head Track Arrangement

opposing current is applied to the supply and takeup reel motors. This arrangement causes the supply motor to oppose the takeup motor and provide hold-back tape tension. A detailed discussion of reel motor operation is presented later in this section. In the event of problems, cleaning the armature is the only maintenance that can be performed. If problems persists, the reel motor should be replaced with a new unit.

4-18. REEL MOTOR BRAKES. Each reel motor has a mechanical brake that is linked to a solenoid (see Detail B, Figure 4-2). The solenoid is operated or deenergized by a control circuit on Mode Control PCA A6. When the solenoid is on, the brakes are off. Brakes are applied when the recorder STOP pushbutton is operated, or when switching from fast forward or fast reverse to a play mode. Detailed discussions of the reel motor brake circuit are also included later in this section.

4-19. REEL COUNTER. The reel counter (see Details A and B, Figure 4-2) is a four-digit mechanical counter with reset. The counter is mechanically linked to the right reel-motor shaft by a pulley-belt arrangement. The counter records each reel revolution, thus providing a direct indication of tape storage.

4-20. PREAMPLIFIER PCA A10. Preamplifier PCA A10 is used to condition reproduce information received from the reproduce head for application to the data channels (FM or direct). The 3964A has four amplifier channels, and the 3968A has eight channels, which are connected to the reproduce head and interconnect PCA A24 by ribbon-type cabling. Preamplifier operation is discussed in conjunction with the descriptions of each type data channel.

4-21. OVERLAP UNITS (OPTION 070 ONLY). Overlap units installed on the transport assembly include a light source, a photo transistor and a rewind-stop selector switch (see Detail A, Figure 4-2). The light source and photo-transistor are positioned so that when the tape on the supply reel (forward play only is used for overlap) is near depletion, the light turns on the photo transistor. The output from the photo-transistor is processed in overlap PCA A9, which generates a signal to turn on the following tape recorder. A second signal, which is subject to an adjustable delay, is also generated and passed to the overlap switch on the transport assembly. The switch position causes the recorder to stop or go to fast reverse (rewind), then stop. The stop or rewind functions are performed on Mode Control PCA A6 and is discussed later in the section.

4-22. ELECTRONIC ASSEMBLIES.

4-23. The recorder electronics are located on printed circuit assemblies (PCA's), most of which are mounted on an interconnecting motherboard (Interconnect PCA A24). All circuit assemblies including optional equipment are shown in Figure 4-4 and described in the following paragraphs. Illustrations locating each assembly in the recorder are presented with the general description of recorder circuits that follow this discussion.

4-24. +5 VDC (B) REGULATOR PCA A1. The +5 Vdc (B) regulated voltage is developed from an unregulated +11 Vdc input that is provided by rectifier CR1 on Interconnect PCA A24. The +5 Vdc (B) supply is routed to Meter Amplifier/10.5V Regulator PCA A3, Speed Control/Bias Oscillator PCA A4, Meter Select/Power Detector PCA A4, Mode Control PCA A6, Calibrator/Servo Control PCA A7, Voice Channel/Servo Loop PCA A8 and Overlap PCA A9 (Option 070 only). The +5 Vdc (B) circuit is illustrated in Figure 7-4.

4-25. CAPSTAN-REEL MOTOR DRIVERS/+5 VDC (A) REGULATOR PCA A2. A portion of this PCA contains drivers for the capstan motor and current sources for the two reel motors. Basic capstan motor drive is developed in Servo Loop PCA A8 and applied to the drivers in PCA A2. The drivers, which operate with +11 Vdc and -11 Vdc, provide the input to the capstan motor assembly that turns the capstan motor. Speed and direction of capstan motor movement is established in PCA A8.

4-26. Two current sources for reel motor operation are located on PCA A2. This first is a 1.2 amp source and the second a 0.8 amp source. These two sources operate from a +11 Vdc unregulated voltage through a matrix consisting of relays K1, K2 and K3 on Interconnect PCA A24. The two current sources are used in the forward and reverse modes of operation only, and are out of the circuit in the fast forward and fast reverse modes. Both a general and detailed discussion of these current sources in reel motor operation is contained in descriptions of mode control later in this section. The capstan drivers and reel motor current sources are shown in Figure 7-8.

4-27. The +5 Vdc (A) regulator portion of PCA A2 provides a regulated +5 Vdc to the data PCA's. The voltage source is the unregulated +11 Vdc derived from rectifier CR1 on Interconnect PCA A24. The circuit contains a conventional regulator with a current limiter and over voltage protection. Distribution of the +5 Vdc (A) is shown in Figure 7-4.

4-28. METER AMPLIFIER/10.5V REGULATOR PCA A3. The meter amplifier portion of PCA A3 accepts record or reproduce data received from the meter select circuit in PCA A5. A two-position switch is provided to route DC, or AC and DC signals through the amplifier. The DC position is used to route record and reproduce data before frequency modulation and after demodulation in the FM Record/Reproduce PCA's. In

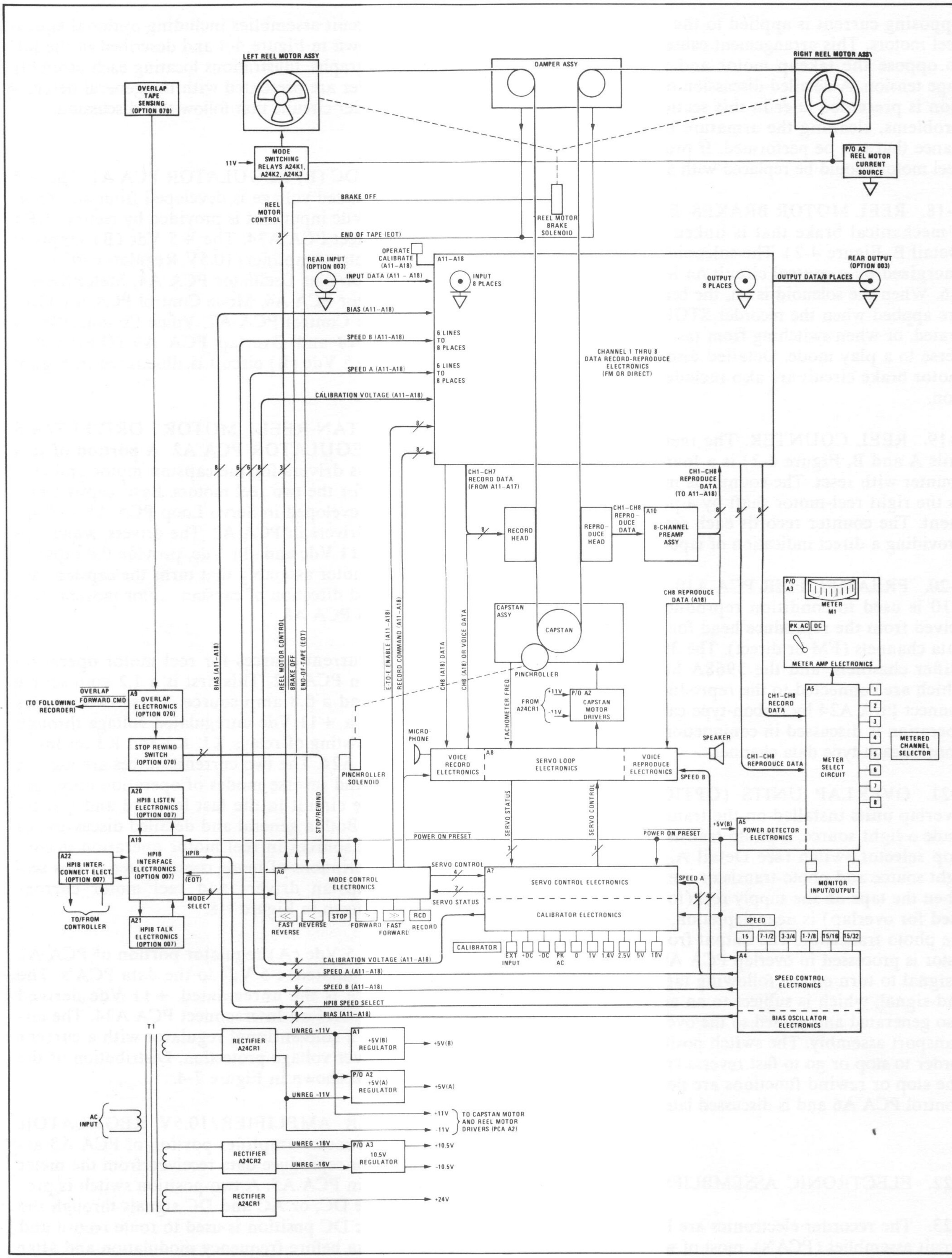


Figure 4-4. Model 3964A/3968A Block Diagram

DC, the signals are routed directly to an output amplifier circuit to the meter. The AC position of the switch is used to pass record and reproduce signals from a Direct Record/Reproduce PCA to rectification and amplification circuits in the motor amplifier. When the switch is in the AC position, the output of the meter amplifier can be calibrated. With the switch in the DC position, the output is uncalibrated, but meter zeroing can be performed. The meter amplifier portion of PCA A3 is used with the FM and Direct Record/Reproduce circuits and is illustrated in Figures 7-34 and 7-41.

4-29. There are two 10.5 Vdc regulator circuits on PCA A3 that are the product of an unregulated +16 Vdc and -16 Vdc supply provided by rectifier CR2 on Interconnect PCA A24. Each of the regulator circuits contain a current limiter, error amplifier and regulator, and provide +10.5 Vdc and -10.5 Vdc to Speed Control/Bias Oscillator PCA A4, Meter Select/Power Detector PCA A5, Mode Control PCA A6, Calibrator/Servo Control PCA A7, Voice Channel/Servo Loop PCA A8, Overlap PCA A9 (Option 070), Preamplifier PCA A10 and both FM and Direct Record/Reproduce PCA's. An illustration of ±16 Vdc and ±10.5 Vdc distribution is shown in Figure 7-9.

4-30. SPEED CONTROL/BIAS OSCILLATOR PCA A4. The speed control portion of PCA A4 provides speed select signals to other units in the recorder. The circuit contains logic encoders and decoders and supplies six Speed A signals (15 ips, 7-1/2 - 15 ips, 3-3/4 ips, 1-7/8 ips, 15/16 ips and 15/32 ips) to the recorder electronics. The Speed A signals are used by Servo Control PCA A7 to establish an internal reference signal, and by the FM Record/Reproduce PCA's to select an FM carrier and provide FM demodulation. Four Speed B signals (3-3/4 ips, 1-7/8 ips, 15/16 ips and 15/32 ips) are used to select equalization circuits in Voice Record/Reproduce PCA A8 and six Speed B signals (15 ips, 7-1/2 ips, 3-3/4 ips, 1-7/8 ips, 15/16 ips and 15/32 ips) are used to select equalization circuits in the FM Record/Reproduce PCA's. The same six Speed B signals are used to select equalization and filter circuits in the Direct Record/Reproduce circuits. The speed can also be selected by a remote controller through the HP-IB electronics or from a remote control unit (not illustrated in Figure 4-4). Distribution of all speed-select signals is illustrated in Figure 7-12.

4-31. The bias oscillator portion of PCA A4 supplies an AC bias that is used in the Direct Record/Reproduce PCA's, in the voice record section of PCA A8, and in FM Record/Reproduce PCA's when the units are installed with Direct PCA's. The AC bias is used in the record section of the direct units to record an AC signal to minimize distortion during the record process, and in an FM unit to prevent cross talk between the FM and direct units. A detailed discussion of bias is presented in the discussions of the FM and Direct Record/Reproduce circuits. The bias circuit is shown functionally in Figures 7-34 and 7-41.

4-32. METER SELECT/POWER DETECTOR PCA A5. The meter select portion of PCA A5 provides a means of directing either the record data or reproduce data from any channel to the meter amplifier circuit in PCA A3 for display on meter M1. Channel selection is provided by pushbuttons on the front of the module, and selection of the selected channels record or reproduce data is made by use of the MONITOR OUTPUT (reproduce) and INPUT (record) pushbuttons also located on the front of PCA A5. The meter select circuit is used with the FM and Direct Record/Reproduce circuits and is illustrated in Figures 7-34 and 7-41.

4-33. The power detector circuit on PCA A5 contains a voltage sensing circuit with turn-on delay and fast turn-off. The circuit senses the +5 Vdc (B) supply, and provides low Power On Preset signal to PCA A4, PCA A6 and PCA A7 in the standard recorder, and to PCA A19 when the HP-IB option (Option 007) is installed. This low output is maintained for approximately 250 milliseconds after turn-on, and clears logic circuits in the aforementioned PCA's. The power detector circuit is shown functionally with the mode control circuit in Figure 7-16.

4-34. MODE CONTROL PCA A6. The mode control PCA contains logic circuits to control tape movement and the record and stop functions. Six pushbuttons are mounted on the front of the module to control the forward, reverse, fast forward, fast reverse, record and stop functions. These pushbutton controls are paralleled by six input control lines from the HP-IB electronics when Option 007 is installed in the recorder, and by six remote control lines to permit use of the recorder with a user-supplied remote control unit.

4-35. The mode control PCA controls operation of the reel motor brake and the pinchroller. In forward and reverse the pinchroller is in against the capstan to move the tape. When a fast forward or fast reverse mode is selected, the pinchroller is out and tape movement is controlled by the reel motors. The brake is applied when a stop is initiated or the power is removed. Recorder operation is started when a mode command is received. The mode control PCA operates with the Servo control electronics on PCA A7 to control capstan motion, and receives motion and phase lock status signals back from PCA A7 to control pinchroller/brake operation and record logic.

4-36. The Mode Control PCA also controls operation of the reel motors through three relays located on Interconnect PCA A24. During forward and reverse operation the reel motors maintain tape tension and the capstan pinchroller assemblies control tape speed. In the fast modes, the reel motors control both speed and tension. When recording, a Record Command signal is generated by PCA A6. This signal is used by the FM or direct modules and the Voice Record/Reproduce circuit in PCA A8 to connect the record electronics to the record head. The E-to-E (electronics-to-electronics)

Enable signal is used to connect the record electronics to the reproduce electronics in the FM Record/Reproduce PCA's. This connection is made when the servo system is out of lock, when switching from forward to reverse, when switching from reverse to forward and when recording in the reverse mode. This function provides a stable output signal while these operations are in process.

4-37. The mode control PCA also monitors tape useage. When tape runs out, or breaks, an EOT (end of tape) signal is generated by the damper assembly. The signal causes the recorder to stop after a short delay. If HP-IB electronics are installed (Option 070), the EOT signal is used to notify the controller that a problem exists in the recorder. If the recorder is operating in an overlap mode (Option 070), Mode Control PCA A6 provide the overlap electronics with an enabling signal. Overlap is used to connect two or more recorders together electrically. When the first recorder tape supply is low, the following recorder starts operation. A tape sensing circuit near the left reel provides an indication when tape is low. If an enable signal is present from PCA A6, an Overlap Forward Command and Overlap Record Command are sent to the following recorder to start that recorder. A second signal is sent back through a switch to PCA A6 that stops or rewinds the tape. The mode control circuits are functionally illustrated in Figures 7-15 through 7-18.

4-38. CALIBRATOR/SERVO CONTROL PCA A7. The calibrator portion of PCA A7 develops AC and DC voltages that are used in the FM and direct PCA's to calibrate the record and reproduce electronics. Voltages available include AC, +DC, and -DC in six ranges from 0 to 10 volts. The calibrator also can accept an externally supplied calibration voltage and contains a switch to route this external voltage to the data PCA's.

4-39. The servo control portion of PCA A7 operates in conjunction with the servo loop portion of PCA A8 to control the capstan operation. The servo control electronics develops the internal reference frequency that is used to phase-lock the capstan motor at the speed selected in Speed Control PCA A4. The electronics also includes circuits that control capstan motor on-off operation and forward or reverse motion of the capstan. When a tape reference frequency is used instead of the tachometer frequency for phase locking the capstan assembly, PCA A7 provides the control signal to PCA A8 to enable the tape frequency input circuit. The unit also provides two status signals to Mode Control PCA A6 that are used in the brake and pinchroller control circuits, and in the record control circuit.

4-40. VOICE CHANNEL/SERVO LOOP PCA A8. The voice channel portion of PCA A8 contains the voice record and reproduce electronics. Normally, channel 4 record data in the 3964A and channel 8 data in the 3968A is routed through the voice record section of PCA A8 and then applied to the record head. To make a voice recording, a microphone is installed in the PCA MICROPHONE jack (front panel accessible). When the record command from PCA A6 is active and the microphone push-to-talk button is pressed, the normal data path is interrupted and the microphone input is recorded on tape track 4 in the 3964A and track 8 in the 3968A. The track 4 reproduce data in the 3964A and track 8 data in the 3968A that is passed through Preamplifier PCA A10 to the voice reproduce section of PCA A8. During FM or direct operation, the reproduce data is processed and appears on the module output jack. During voice operation, the reproduce data is processed in PCA A8 and applied to the output speaker on the front of the module. The voice data also is applied to the associated FM or direct module; however, with an FM PCA installed in location A14, the FM carrier output from the PCA is not demodulated so sounds distorted and unusable.

4-41. The servo loop portion of PCA A8 contains the electronics to provide drive to the capstan motor. An internally generated or externally supplied reference frequency is initially applied to the capstan motor drive circuit through servo loop electronics. As the capstan motor turns, a tachometer in the capstan motor assembly feed back a tachometer frequency to Servo Loop PCA A8. When the tachometer frequency equals the reference frequency servo phase lock occurs, and the motor continues to run at the speed established by the reference frequency. As previously discussed, PCA A8 circuits operate under control of the servo control electronics in PCA A7 and both circuits are discussed in detail later in this section.

4-42. OVERLAP PCA A9 (OPTION 070 ONLY). The overlap PCA is used to electrically connect two recorders in series so that the second recorder starts before the first stops. Any number of recorders can be connected in this manner to provide long-term, unattended operation. The functions of overlap electronis are under control of Mode Control PCA A6 and is illustrated in Figure 7-31.

4-43. PREAMPLIFIER PCA A10. The preamplifier assembly is located in the transport assembly and is described in paragraph 4-20.

4-44. FM RECORD/REPRODUCE PCA. Up to four FM Record/Reproduce PCA's can be installed in the 3964A and eight in the 3968A, or the assemblies can be intermixed with the Direct Record/Reproduce PCA's. The FM assemblies are used with low frequency AC or DC inputs providing excellent amplitude stability and signal-to-noise ratio. The record electronics includes a frequency modulation circuit that develops a carrier frequency which is established by the speed selected at PCA A4. The modulated FM carrier is then passed to the head for recording. The FM data from the tape is first passed through Preamplifier A10 and then is demodulated in the reproduce section. The

demodulation circuit is also operated by speed signals developed in PCA A4. The Speed A signals are used to set the modulation and demodulation circuits. The reproduce electronics also contains three stages of equalization, which are speed dependent. The Speed B signals from PCA A4 are used to set the equalization circuits. Demodulated reproduce signals are available at the OUTPUT jack for cable connection to display devices. The functions of the bias, E-to-E and calibration circuits are discussed in paragraphs 4-31, 4-36 and 4-38 respectively.

4-45. DIRECT RECORD/REPRODUCE PCA. Up to four Direct Record/Reproduce PCA's can be installed in the 3964A and eight in the 3968A, or the assemblies can be intermixed with the FM Record/Reproduce PCA's. The direct assemblies are used with AC frequencies between 100 Hz and 64 kHz. Input data is amplified and recorded on tape using the bias described in paragraph 4-30. Reproduce data received through Preamplifier PCA A10 is passed through upper band, midband, low band and phase equalization circuits and a low pass filter. The upper band, midband and phase equalization requirements change with speed, therefore, Speed B select signals are used to provide correct equalization at each tape speed. The Speed A select signals are not used in direct assemblies. Calibration voltages established in PCA A7 are used to calibrate the direct electronics. The E-to-E enable signal is not used in direct electronics.

4-46. INTERFACE PCA A19 (OPTION 007 ONLY). Interface PCA A19 is one of four assemblies that are used to remotely operate the recorder using HP-IB (Hewlett-Packard Interface Bus) control. PCA A19 contains the control word decoder, buffers, and a connector for interfacing the HP-IB electronics to the recorder speed and mode control electronics on PCA A4 and PCA A6 respectively. Interface PCA A19 also provides interconnection between Listen Control PCA A20 and Talk Control PCA A21.

4-47. LISTEN CONTROL PCA A20 (OPTION 070 ONLY). Listen Control PCA A20 also is part of the HP-IB installation. The logic on the assembly operates with the remote controller to transfer command data from the controller to the decoder on PCA A19. The assembly operates on a "handshake" basis with the controller, using the short "handshake" to set up listen address transfers and a long "handshake" for transferring the control data.

4-48. TALK CONTROL PCA A21 (OPTION 007 ONLY). Talk Control PCA A21 monitors the end of tape (EOT) condition in the recorder. If an EOT situation exists, the PCA makes a service request to the controller. The PCA also contains logic to provide identification to the controller when a service request is generated. This identifies the recorder as the requesting device.

4-49. INTERCONNECT PCA A22 (OPTION 007 ONLY). The interconnect PCA contains connectors that hold PCA's A19, A20 and A21, and the connector used to interface the HP-IB electronics with the controller. The PCA also holds a five-position switch that is used to establish the recorder's ASCII Address. The switch is accessible on the recorder rear panel. PCA A22 also contains signal line buffering devices and inverter to convert negative-true I/O information into positive-true logic for use in PCA's A19, A20 and A21.

4-50. INTERCONNECT PCA A24. The interconnect PCA, which is not shown in Figure 4-4, contains the connectors that hold PCA's A1 through A9 and A11 through A14 (3964A) or A11 through A18 (3968A). The board also contains the signal and power interconnection between PCA's essential for recorder operation. The discreet rectification and filtering components that are part of the ±16 Vdc, ±11 Vdc and +24 Vdc supplies are located on the PCA, as well as a connector for remote control of the recorder. The latter connector is accessible from the rear panel.

4-51. MODE CONTROL OPERATION.

4-52. The mode control electronics are located on PCA A6 (see Figure 4-5). Three methods of controlling recorder operations are available: from assembly switches that are front-panel accessible; from a remote controller through the HP-IB electronics; and from a remote source using the remote control connector on PCA A24. In the latter operation, both the control unit and interconnecting cable are supplied by the user. Any input mode control signal is a momentary low that sets a latch in the mode control logic. The following discussion contains a summary of events that occur in each mode.

4-53. When power is first applied to the recorder, the Power On Preset input remains low for approximately 250 milliseconds. This low input is applied through the run-stop logic to clear various circuits. After time-out of the preset delay, the Power On Preset signal goes high and enables the brake and pinchroller delay control circuit.

4-54. Receipt of any input forward command sets the forward-reverse logic to forward, slow-fast logic to slow, and run-stop logic to run. Outputs from the three logic circuits are applied to the lamp control logic to light the forward pushbutton lamp and send a Forward Command to PCA A7 for capstan motor direction control. The outputs from the three circuits also provide an active Run Selected signal, and inactive Fast Selected and Reverse Selected signals from the reel motor relay control circuit. The state of these outputs cause relays A24K1, A24K2 and A24K3 to set the reel motor supply current for forward tape motion (see Detail A, Figure 4-6). One output from the run-stop logic and an output of the slow-fast logic are combined at the brake

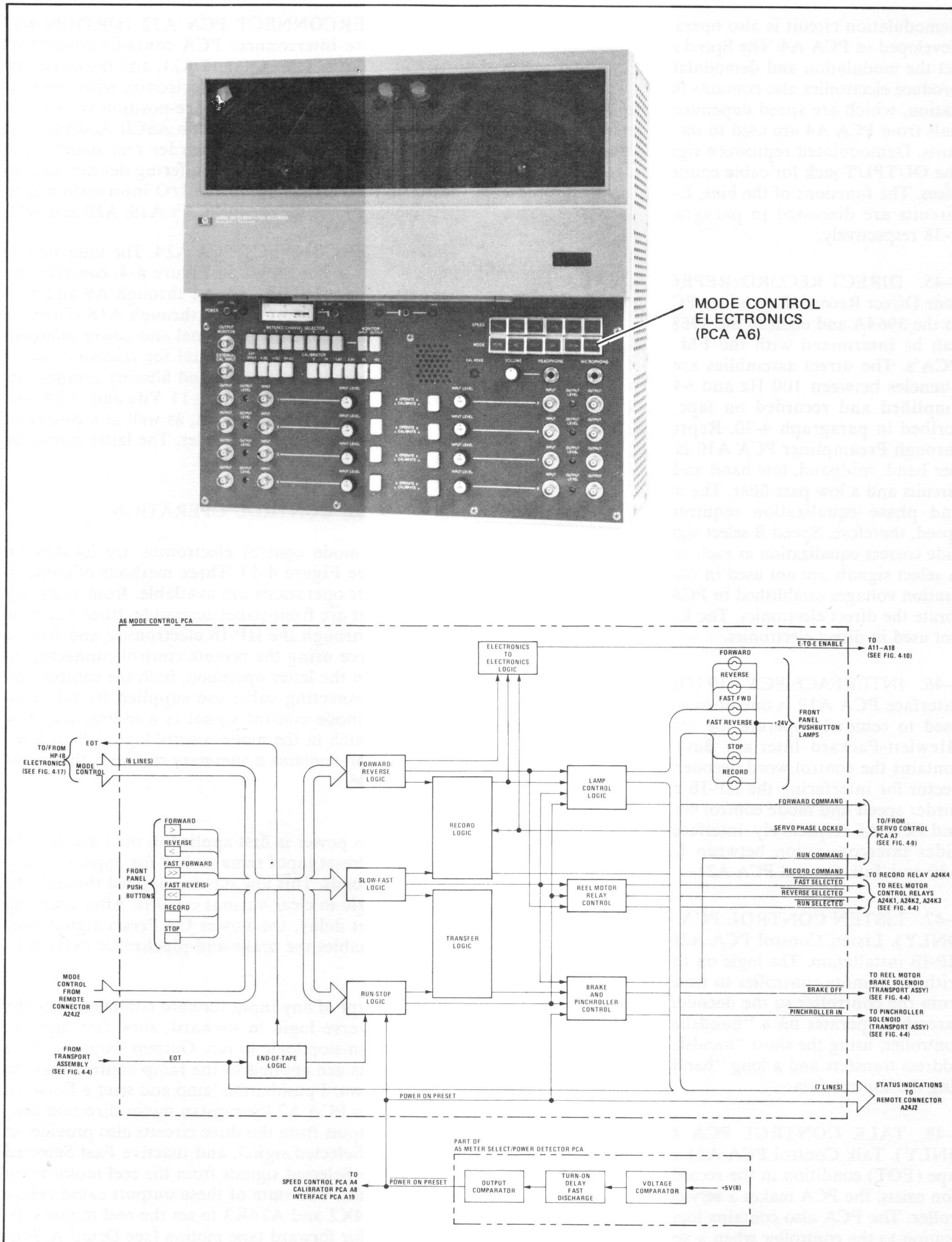


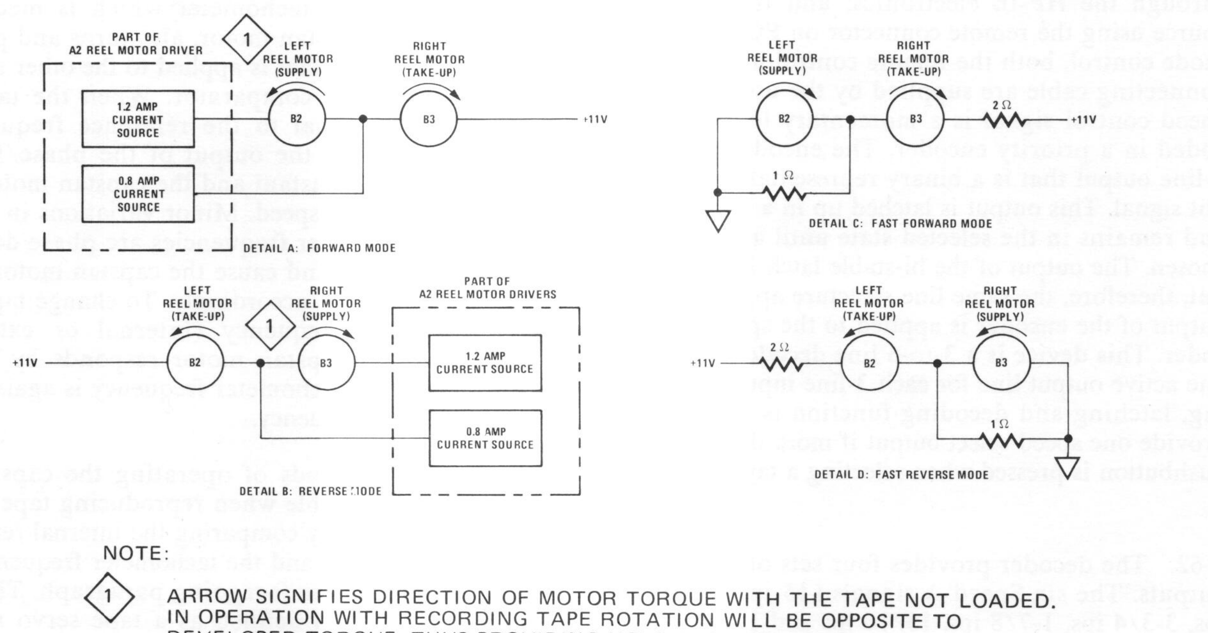
Figure 4-5. Mode Control Electronics, Simplified Block Diagram

and relay control circuit. With Power On Preset timed out and no transfer (fast-to-stop or fast-to-slow) in progress, the control circuit is enabled. One output of the circuit is a Run Command that is sent to PCA A7 to turn on the capstan motor assembly circuit. Two additional signals are sent to the transport assembly. The Brake Off signal releases the brake, and the Pinchroller In signal causes the pinchroller to be pulled in to hold the tape against the capstan.

4-55. A reverse command at the input circuit also sets the slow-fast logic to slow and run-stop logic to run. However, the forward-reverse logic is set to reverse and the lamp control logic causes the reverse pushbutton lamp to light. The level of the Forward Command signal changes state in reverse operation. This condition causes the capstan direction circuit in PCA A7 to reverse the capstan motor. In the reverse mode, the reel motor relay control circuit now has Run Selected and Reverse Selected active. The two signals cause relays A24K1, A24K2, and A24K3 to change current supply to the reel motors and reverse their movement (see Detail B, Figure 4-6). Brake and pinchroller control circuits operate the same as in forward mode.

4-56. When recording in the forward or reverse mode, the input Record Command is active. A Servo Phase Locked signal from PCA A7 must be active to enable the record logic, which responds by generating a Record Command that energizes relay A24K4. The relay, in turn, provides a +24 Vdc Record Command to the FM or Direct Record/Reproduce Modules. A second output from the record logic is passed to the lamp control logic. When the mode control is set for slow and forward or reverse, the record input to lamp logic lights the record pushbutton lamps. Another output from record logic is applied to electronics-to-electronics logic. When recording in a reverse mode, the E-to-E Enable signal is active and connects the record circuit to the reproduce circuit in the FM Record/Reproduce PCA's. The E-to-E circuit is also active when a transfer occurs in the forward-reverse logic, and if the servo system is out of phase lock as indicated by the Servo Phase Locked status signal from PCA A7.

4-57. In a fast forward or fast reverse mode, the slow-fast logic is set to fast, the run-stop logic is set to run and the forward-reverse logic is set to forward or reverse as selected. The lamp control logic lights the fast forward or fast reverse pushbutton lamps, and the reel motor control provides a Fast Selected and Run Selected outputs along with Reverse Selected when indicated. The reel motors control both tape movement and speed during the fast modes with the reel motor relays controlling this function (see Details C and D, Figure 4-6). In the brake and pinchroller control circuits the Brake Off signal is active, however, the Pinchroller In signal is inactive during fast modes. This function holds the pinchroller out and allows the reel motors to pull the tape across the capstan at full speed.



NOTE:

1 ARROW SIGNIFIES DIRECTION OF MOTOR TORQUE WITH THE TAPE NOT LOADED. IN OPERATION WITH RECORDING TAPE ROTATION WILL BE OPPOSITE TO DEVELOPED TORQUE, THUS PROVIDING HOLD-BACK TENSION.

Figure 4-6. Reel Motor Configuration, Simplified Block Diagram

4-58. Transfer logic is active when switching from a fast mode to a slow mode or from run to stop. When a transfer is initiated by an input command, the transfer logic causes the pinchroller to be pulled out and applies the brake through the brake and pinchroller control current. Timers are installed in the circuit to ensure that all tape motion is stopped before assuming the speed dictated by the new command.

4-59. The end-of-tape (EOT) logic senses the state of the two microswitches in the tape damper assembly. When tape tension is released after a short delay, the EOT logic generates a stop condition in the mode control circuits and sends an EOT signal to the HP-IB electronics. The mode control stop condition inhibits the Run Selected, Brake Off and Pinchroller in signals to stop the reel motors, apply the brake and pullout the pinchroller. The Run Command to PCA A7 is also inhibited to stop the capstan motor. The lamp control logic responds to a normal stop by lighting the pushbutton lamp; however, during an EOT stop the lamp remains out. This gives an indication that the stop is due to lack of tape tension. The EOT in the HP-IB generates a service request to the controller indicating that the recorder needs attention.

4-60. SPEED CONTROL OPERATION.

4-61. The speed control electronics are located on PCA A4 (see Figure 4-7). Recorder tape speed also can be controlled from three locations: from switches that are front-panel accessible; from a remote controller through the HP-IB electronics; and from a remote source using the remote connector on PCA A24. As in mode control, both the remote control unit and interconnecting cable are supplied by the user. Any input speed control signal is a momentary low that is encoded in a priority encoder. The encoder provides a 3-line output that is a binary representation of the input signal. This output is latched up in a bi-stable latch and remains in the selected state until a new speed is chosen. The output of the bi-stable latch follows the input, therefore, the same line structure appearing at the output of the encoder is applied to the speed select decoder. This device is a 3-to-6 line decoder, and makes one active output line for each 3-line input. The encoding, latching and decoding function is performed to provide one speed select output if more than one speed pushbutton is pressed when selecting a tape speed.

4-62. The decoder provides four sets of speed signal outputs. The six Speed A signals (15 ips, 7-1/2 - 15 ips, 3-3/4 ips, 1-7/8 ips, 15/16 ips and 15/32 ips) are sent to Servo Control PCA A7 and to any FM data assemblies installed in the recorder. In PCA A7 the six speed select signals are applied to a divider that is used in the generation of an internal reference frequency. Thus, an active speed select signal provides an internal reference frequency, which is representative of the selected speed to operate the capstan motor in its phase-locked loop. In the FM data PCA's the Speed A signals are used with dividers in the frequency modulation and demodulation circuits.

4-63. The second group of outputs from the speed select decoders are used to illuminate the active pushbutton lamps through a set of lamp drivers. Since the selected line remains active after a pushbutton is released through the bi-stable latch, the selected lamp remains lighted. The six Speed B signals (15 ips, 7-1/2 ips, 3-3/4 ips, 1-7/8 ips, 15/16 ips and 15/32 ips) are used in both the FM and Direct PCA's to FET switches. These speed signals are used to select proper equalization and filter reworks in the reproduce section of the assemblies for the six tape speeds. The last set of six speed signals (15 ips, 7-1/2 ips, 3-3/4 ips, 1-7/8 ips, 15/16 ips and 15/32 ips) are sent to remote control connector J2 on PCA A24 for use in a remote control unit.

4-64. SERVO SYSTEM OPERATION.

4-65. The capstan motor assembly and its servo system are used to control tape speed when recording and reproducing. As an introduction to the functions of the servo system electronics, a simplified tape servo system is shown in Figure 4-8. When recording, a reference frequency developed internally or an external reference frequency is applied through a switching arrangement to one side of a phase/frequency comparator. Immediately upon turn on, this frequency is detected and provides drive to the capstan motor. As the capstan motor starts to turn, a tachometer which is mechanically linked to the capstan motor, also turns and provides a frequency output that is applied to the other side of the phase/frequency comparator. When the tachometer frequency is equal to the reference frequency and locked in phase, the output of the phase/frequency comparator is constant and the capstan motor runs at constant selected speed. Minor variations in the reference or tachometer frequencies are phase detected in the comparator, and cause the capstan motor to speed up or speed down accordingly. To change tape speeds, the reference frequency (internal or external) is changed. The capstan motor responds by changing speed until the tachometer frequency is again equal to the reference frequency.

4-66. Two methods of operating the capstan servo system are available when reproducing tape information. The first is by comparing the internal reference or external reference and the tachometer frequency output as described in the foregoing paragraph. The second method, which is defined as a tape servo mode, involves using the same reference frequency during reproduction that was used when the data was recorded. This requires recording the reference frequency on one track of the tape, and using the remaining tracks to record data. The result is to lock the reproduced tape

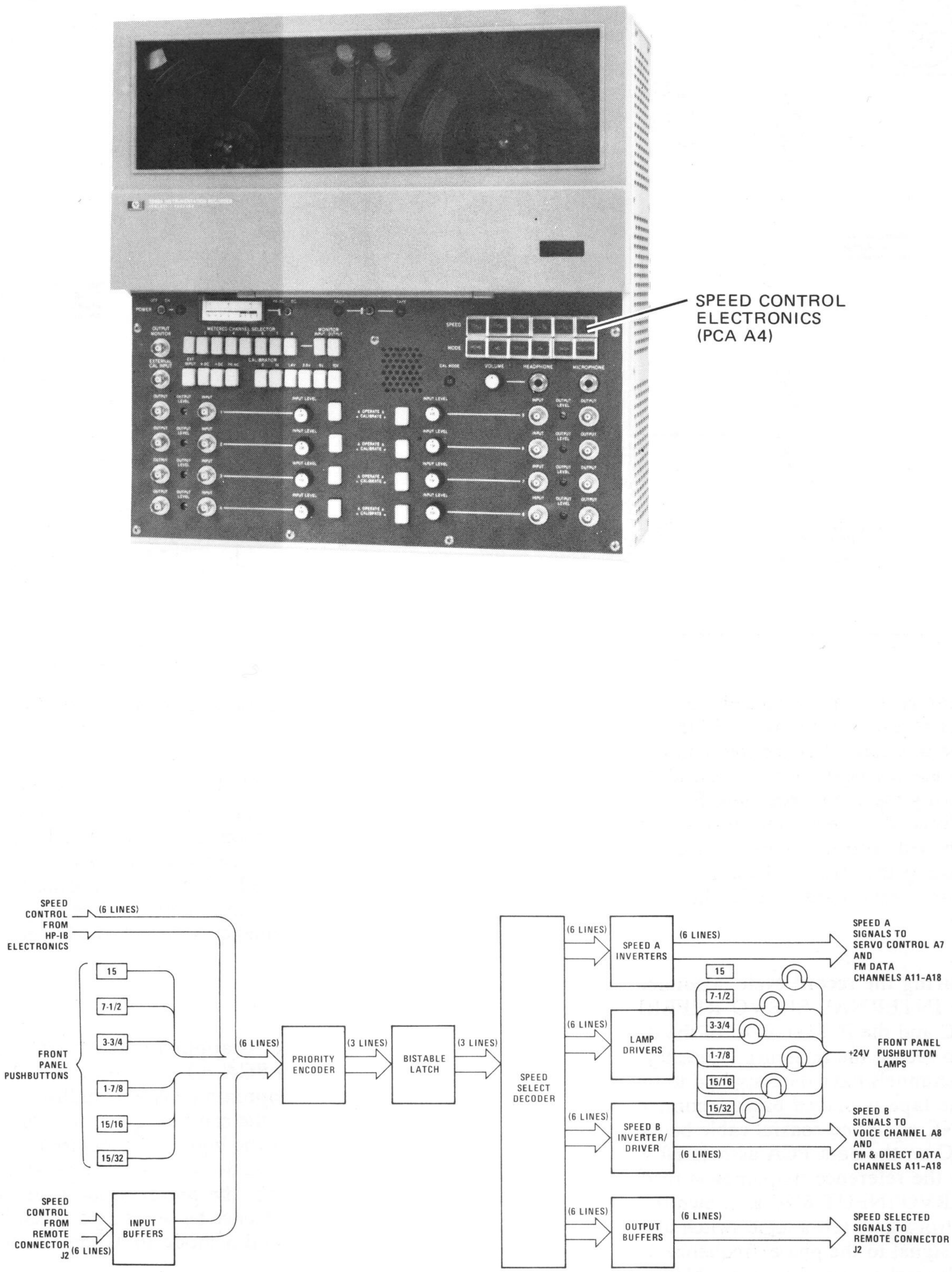


Figure 4-7. Speed Control Electronics, Simplified Block Diagram

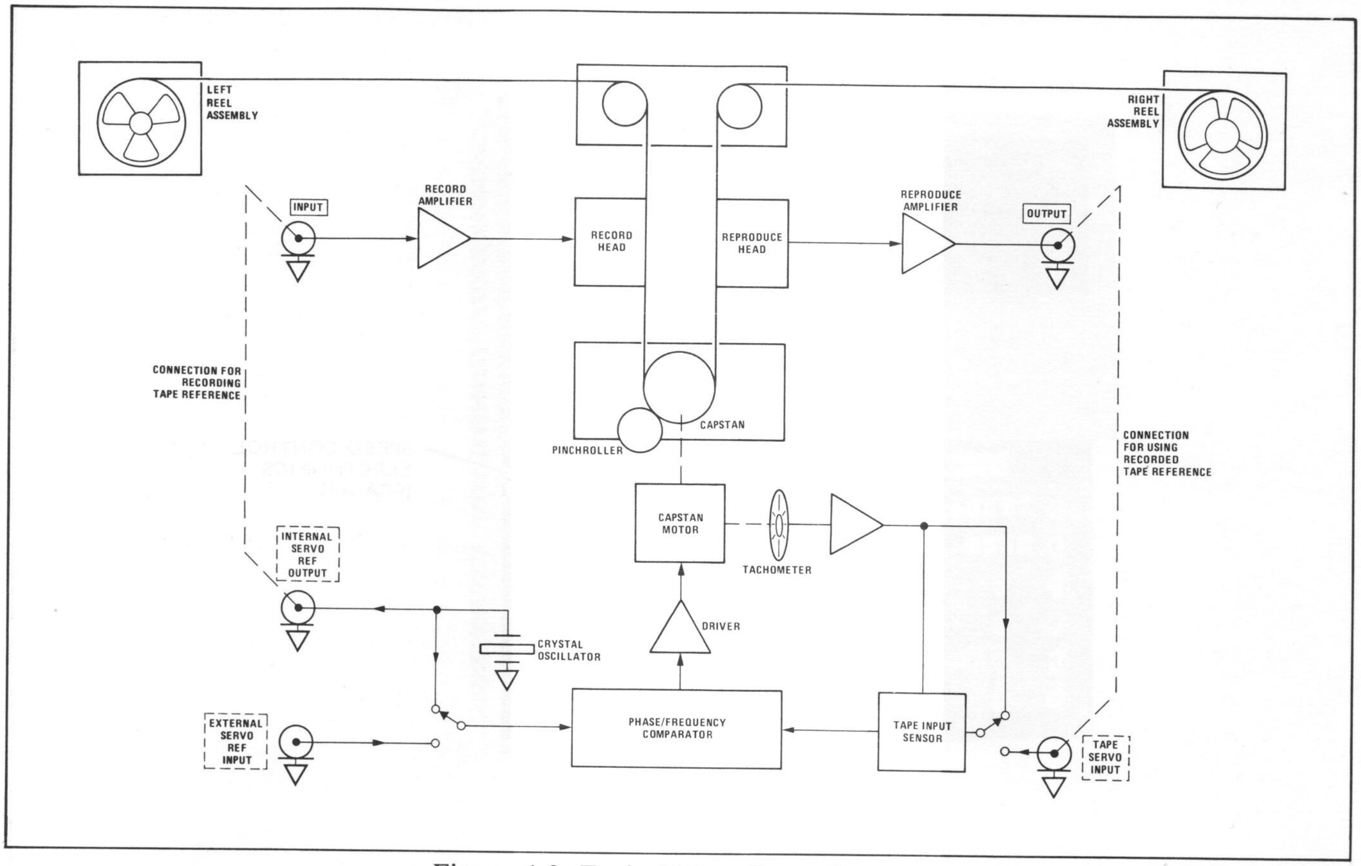


Figure 4-8. Typical Tape Servo System

speed exactly to the recorded speed. The normal method is to use one channel of direct electronics to record the internal reference frequency. When it is desirable to use the tape servo mode and flutter compensation during the same operation, FM electronics must be used. Special jumper connections must be made on the FM board, and is discussed later in this section. Track 2 using the channel 2 electronics is recommended for tape servo mode use in the Model 3964A or 3968A.

4-67. During the record cycle, a connection is made from the INTERNAL SERVO REFERENCE OUTPUT BNC and the INPUT BNC of the data channel to be used to record the reference frequency. The remaining data channels have data applied to the input jacks. Before the tape is played back, a connection is made with a BNC equipped coaxial cable between the OUTPUT BNC on the data PCA associated with the track on which the reference frequency is recorded and the TAPE SERVO INPUT BNC as shown in Figure 4-8. A servo control signal sets a logic switch to apply the tape reference signal to the phase/frequency comparator instead of the tachometer frequency. Now, a comparison is made between the reference frequency and previously recorded tape frequency, and the capstan motor moves the tape across the heads at the recording speed. In the event of a tape reference input failure, the servo system has a sensing circuit which automatically switches the system back to the tachometer frequency when a failure occurs. This feature prevents capstan motor runaway.

4-68. The Model 3964A/3968A servo system electronics is contained on three PCA's (see Figure 4-9), with the control electronics on PCA A7, the phase/frequency circuits on PCA A8 and capstan motor power amplifiers on PCA A2. The following general description assumes that an internal reference frequency and the tachometer frequency are used to control servo operation.

4-69. When power is applied to a recorder, a power detector circuit on PCA A5 provides a low Power On Preset signal for approximately 250 milliseconds. This signal is applied to the capstan motor control circuit in PCA A7 and clears the logic. This feature ensures that the logic is set correctly to start an operation. After time-out on PCA A5, the preset signal goes high and operations can commence by selecting a speed in Speed Control PCA A4 and a mode in Mode Control PCA A6.

4-70. Selecting a speed causes one of the six Speed A input lines to the frequency divider on PCA A7 to become active. The divider then divides down an oscillator frequency, and provides an Internal Reference Frequency that is directly related to the selected speed.

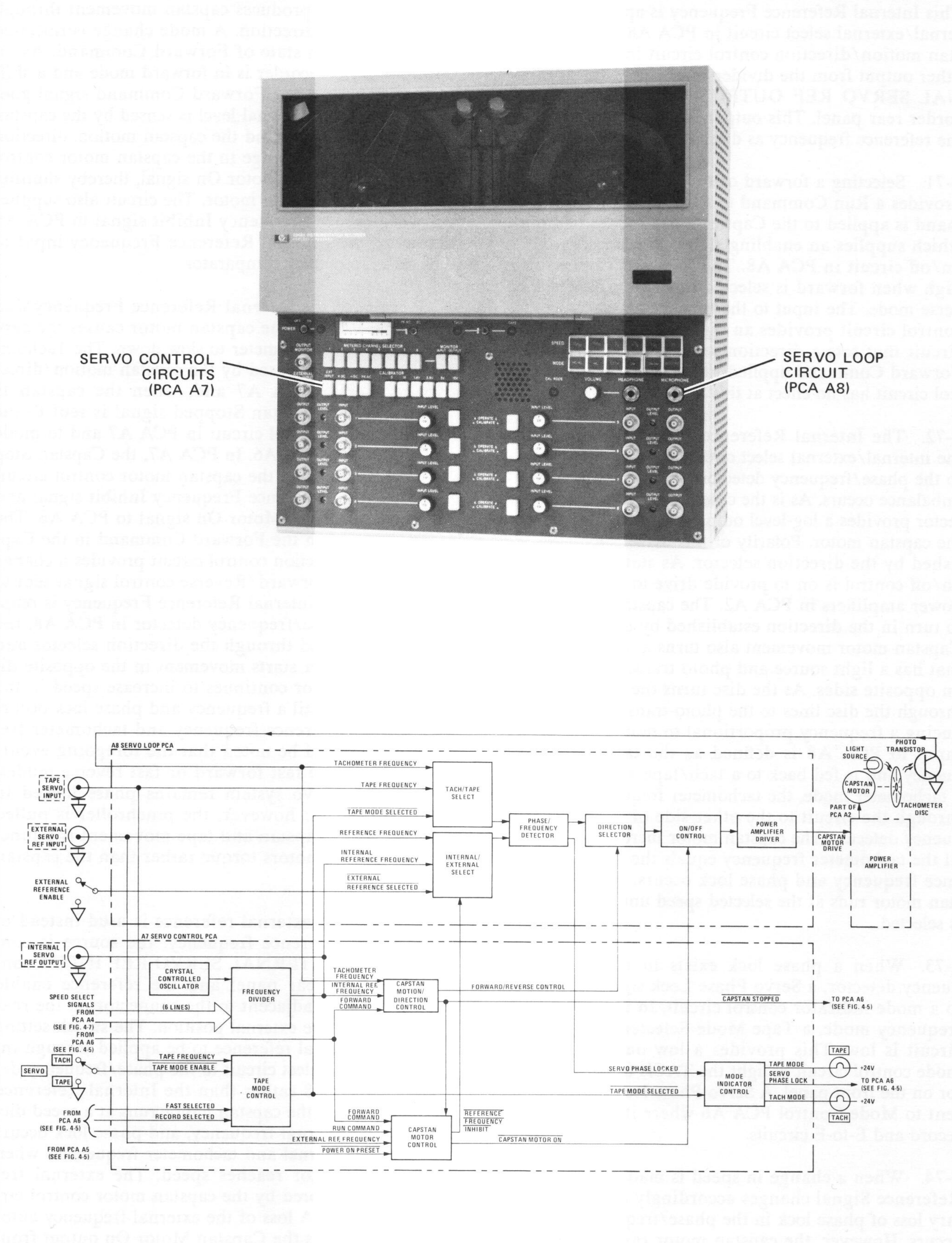


Figure 4-9. Servo Electronics, Simplified Block Diagram

This Internal Reference Frequency is applied to an internal/external select circuit in PCA A8, and to a capstan motion/direction control circuit in PCA A7. Another output from the divider is passed to the INTERNAL SERVO REF OUTPUT connector on the recorder rear panel. This output is used when recording the reference frequency as discussed in paragraph 4-67.

4-71. Selecting a forward or reverse mode in PCA A6 provides a Run Command to PCA A7. The Run Command is applied to the Capstan Motor Control circuit, which supplies an enabling signal to a capstan motor on/off circuit in PCA A8. The Forward Command is high when forward is selected and low when in a reverse mode. The input to the capstan motion/direction control circuit provides an output from the direction circuit that sets a direction selector in PCA A8. The Forward Command applied to the capstan motor control circuit has no effect at this time.

4-72. The Internal Reference Frequency applied to the internal/external select circuit in PCA A8 is passed to the phase/frequency detector where initially a phase unbalance occurs. As is the case during start up, the detector provides a log-level output that provides drive to the capstan motor. Polarity of this drive input is established by the direction selector. As stated before, the on/off control is on to provide drive to the driver and power amplifiers in PCA A2. The capstan motor starts to turn in the direction established by driver polarity. Capstan motor movement also turns a tachometer disc that has a light source and photo transistor connected on opposite sides. As the disc turns the light is passed through the disc lines to the photo-transistor, thus producing a frequency proportional to motor speed. This input to PCA A8 is defined as the tachometer frequency and is fed back to a tach/tape select circuit. In a tachometer mode, the tachometer frequency is passed through the circuit to the other side of the phase/frequency detector. The capstan motor increases speed until the tachometer frequency equals the internal reference frequency and phase lock occurs. Now, the capstan motor runs at the selected speed until a new speed is selected.

4-73. When a phase lock exists in the phase/frequency detector, a Servo Phase Lock signal is applied to a mode indicator control circuit. In the tachometer frequency mode, a Tape Mode Selected signal to the circuit is low. This provides a low output from the mode control circuit to light the TACH SERVO indicator on the front panel. A Servo Phase lock signal is also sent to Mode Control PCA A6 where it is used in the record and E-to-E circuits.

4-74. When a change in speed is made, the Internal Reference Signal changes accordingly and a momentary loss of phase lock in the phase/frequency detector occurs. However, the capstan motor rapidly moves to the new speed and a new phase lock is made between the tachometer and Internal Reference Frequencies. A change in mode produces capstan movement through stop to the new direction. A mode change is initiated by the change in state of Forward Command. As an example, if the recorder is in forward mode and a shift to reverse occurs, the Forward Command signal goes low. The change in signal level is sensed by the capstan motor control circuit and the capstan motion/direction control. The level change in the capstan motor control inhibits the Capstan Motor On signal, thereby shutting off drive to the capstan motor. The circuit also supplies a low Reference Frequency Inhibit signal to PCA A8 that stops the Internal Reference Frequency input to the phase/frequency comparator.

4-75. Loss of the Internal Reference Frequency and inhibiting drive to the capstan motor causes the capstan motor and tachometer to slow down. The Tachometer Frequency is sensed by the capstan motion/direction control in PCA A7 and, when the capstan is stopped, a low Capstan Stopped signal is sent to the capstan motor control circuit in PCA A7 and to mode control logic in PCA A6. In PCA A7, the Capstan Stop signal clears logic in the capstan motor control circuit to remove the Reference Frequency Inhibit signal and restore the Capstan Motor On signal to PCA A8. The change of state in the Forward Command in the Capstan motion/direction control circuit provides a change in state of the Forward/Reverse control signal sent to PCA A8. As the Internal Reference Frequency is reapplied to the phase/frequency detector in PCA A8, the output is reversed through the direction selector and the capstan motor starts movement in the opposite direction. The motor continues to increase speed in the new direction until a frequency and phase lock occurs between the reference frequency and tachometer frequency. It should be noted that the foregoing events also occur in the fast forward or fast reverse modes. The capstan servo system remains phase locked in these fast modes; however, the pinchroller is pulled away from the capstan and tape movement is a function of the reel motors torque rather than the capstan speed.

4-76. When an external reference is used instead of the internal reference frequency, the source is connected to the EXTERNAL SERVO REF INPUT connector on the rear panel and the reference enable switch, which is adjacent to the connector on the rear panel, is set to the external position. The switch setting causes the external reference to be applied through internal/external select circuit to the phase/frequency detector in PCA A8 rather than the Internal Reference Frequency. Now the capstan motor runs at a speed dictated by the external frequency, and phase lock occurs between the external and tachometer frequencies when the capstan motor reaches speed. The external frequency is monitored by the capstan motor control circuit in PCA A7. A loss of the external frequency automatically inhibits the Capstan Motor On output from the capstan motor control circuit to remove drive to the capstan motor.

4-77. When the recorder is to be operated in the tape frequency mode, as described in paragraphs 4-66 and 4-67, the tape frequency input is made at the TAPE SERVO INPUT connector on the rear panel. A cable connection from the output jack of the data PCA associated with the tape track on which the reference frequency is recorded is made to the TAPE SERVO INPUT connector. The input tape frequency is applied to the tach/tape select circuit in PCA A8, and to a tape mode control circuit in PCA A7. The latter circuit is enabled by the following four conditions: the front-panel SERVO switch being set to TAPE; the recorder set to a slow mode (a low Fast Selected signal); the instrument not in a record mode (a low Record Selected signal); and the presence of the tape frequency input. When the conditions are satisfied a low tape mode selector signal is passed to the tape/tach select circuit in PCA. This enabling signal inhibits the Tachometer Frequency, and now the phase/frequency detector operates with the tape frequency and the Internal Reference Frequency. Phase lock between the two frequencies causes the capstan motor to run at the same speed as dictated by the recorded tape frequency. One output from the tape mode control circuit in PCA A7 is applied to the mode indicator control circuit. When Servo phase lock occurs in the tape mode, the Tape Mode output signal becomes active to light the front-panel TAPE lamp.

4-78. In the event that the recorded tape frequency input is interrupted, the tape mode control circuit in PCA A7 automatically inhibits the Tape Mode Selected output to PCA A8. The tach/tape select circuit automatically switches the tachometer frequency input to the phase/frequency detector and the recorder continues to operate at the speed dictated by the Internal Reference Frequency. The change in level of the Tape Mode Selected signal to the mode indicator control circuit in PCA A7 causes the TAPE lamp to extinguish and the TACH mode to light. If a fast mode (fast forward or fast reverse) is selected, or the record mode is selected, the respective inputs to PCA A7 go high and affect the tape mode control circuit in the same manner as the loss of a tape input. The Servo system automatically shifts to the tach mode when any of these circumstances occur. A more detailed discussion of the servo system is presented later in this section.

4-79. FM DATA ELECTRONICS.

4-80. The FM data electronics includes both record and reproduce circuits on a single PCA, which can be installed in any one of four data channel positions (A11 through A14) in the 3964A or eight positions (3968A) in the 3968A. A recorder can be equipped with FM Record/Reproduce PCA's, or any number can be mixed with Direct Record/Reproduce PCA's. The following discussion provides separate descriptions of the record section and reproduce sections. Detailed descriptions are presented later in this section.

4-81. FM RECORD ELECTRONICS. The record electronics (see Figure 4-10) is used to frequency modulate a carrier with DC to 5 kHz data in preparation for recording on tape. Input data is applied to a PCA through the INPUT BNC connector on the front of the module, or from a rear-panel BNC if Option 003 is incorporated. The data is first applied to an OPERATE-CALIBRATE switch in the input circuit. When the switch is in the CALIBRATE position a calibration voltage is applied to the PCA from PCA A7. This voltage can be AC or DC. The DC voltage can be positive or negative, and six AC or DC voltage levels can be selected from zero volts to 10V. This calibration voltage is used to set various circuit board adjustments for specific recording/reproduction applications. After calibration, the switch on the FM PCA is set to OPERATE and input data is passed through an INPUT LEVEL control to input and level shifting amplifier stages.

4-82. An offset selector jumper arrangement is connected in the input amplifier circuit. When the polarity of the data to be recorded is known, offset can be used to increase the signal-to-noise ratio when reproducing the signal. As an example if a signal is to be recorded that is varying only in a positive direction from zero volts to +2.5V, negative offset can be used to move the starting reference so that the entire recording range is used. The level shifting amplifier is used to provide a proper signal level to the voltage controlled oscillator that follows.

4-83. The voltage controlled oscillator (VCO) and programmed frequency divider are combined to frequency modulate the input data. The oscillator's output frequency is modulated at the input data rate. This varying frequency is then applied to the programmed frequency divider whose division rate is established by one active Speed A line of six lines received from PCA A4. If a speed of 3-3/4 ips is selected in PCA A4, that active line sets the programmed divider to divide the VCO input frequency down to the frequency associated with the selected speed. This modulated carrier is applied through a dubbing input selector to the record head drivers.

4-84. The output of the record head drivers can be mixed with a bias input that is derived from a bias oscillator circuit on PCA A4. When the recorder is equipped with FM PCA's only, the bias circuit in the FM record electronics is not used. When the FM PCA's are mixed with Direct Record/Reproduce PCA's bias is used to lower the recording level and prevent cross talk between FM and direct channels. The bias oscillator is turned on only when a record command from PCA A6 is active. This Record Command is generated when the RECORD pushbutton is operated, or when an HP-IB or Remote Command is received in PCA A6.

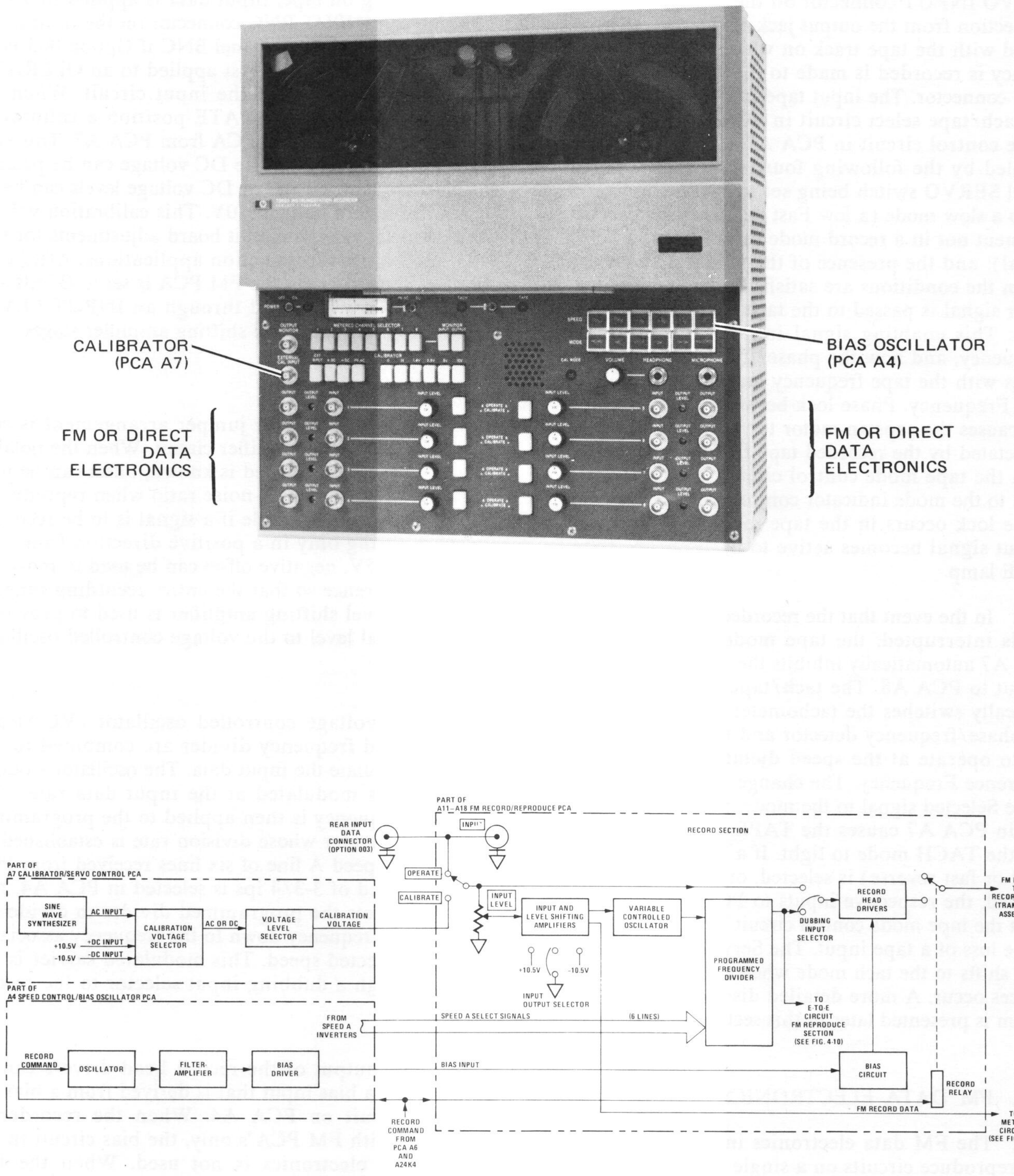


Figure 4-10. FM Record Electronics, Simplified Block Diagram

4-85. The Record Command is also required to energize the record relay in the FM PCA. This connects the output of the record head drivers to the record head in the transport assembly and then to the tape track associated with the FM module. The FM data output from PCA A14 (Channel 4) in the 3964A and PCA A18 (Channel 8) in the 3968A is first passed to relay contacts in the record section of the voice record/reproduce circuit on PCA A8. If a voice recording is not being made, the FM data is sent back to the record head. The output from the programmed divider that is sent to the electronics-to-electronics (E-to-E) circuit in the reproduce circuit is used to bypass the record and reproduce heads at certain times. Both the record and reproduce heads are bypassed when the servo system is out of phase lock or when a fast mode is selected. The reproduce head is bypassed when a recording is made in the reverse mode.

4-86. The dubbing input and output selectors on the FM PCA's are set to dubbing when making a duplicate tape. Two tape recorders are used to perform this function. The tape to be duplicated is installed in the first recorder, and the dubbing output selector jumper on each FM PCA in the instrument is set to the dubbing position. A connection from the OUTPUT connector on each FM PCA in the first recorder is then made to the INPUT connector on the associated FM PCA in the second recorder. The input dubbing connector on each FM PCA in the second instrument is set to the dub (D) position thus completing the recording chain. The first instrument is set to FORWARD PLAY and the second instrument is set to forward-record to make the duplicate recording.

4-87. FM REPRODUCE ELECTRONICS. The reproduce electronics (see Figure 4-11) are used to amplify and demodulate frequency modulated data retrieved from the recording tape, and process the data for use with instrumentation equipment. Data from the tape is initially received from the reproduce head and amplified in Preamplifier PCA A10. This circuit board, which is located near the reproduce heads in the transport assembly, has a sensitive current amplifier for each track. The preamplifier output is first applied to a data equalizing and squaring amplifier circuit in the FM PCA. The data equalizer circuit is used to provide high frequency boost to equalize for recording losses, with equalization controlled by an input speed-select signal from PCA A4. Equalization is fixed at 15 ips, but capacitance is added in five increments at speed selections from 7-1/2 ips to 15/32 ips. The squaring amplifier is used to square the input FM signal by clipping at a fixed level and provides signal gain.

4-88. The output of the squaring amplifier circuit is fed to a phase-detector circuit that is connected in a phase-lock loop with a filter, variable controlled oscillator and a programmed frequency divider. The divider is set by input speed-select signals from PCA A4. Changes from the normal 90 degree phase shift between the two inputs occur as a result of the modulating data on the input carrier. This data is filtered through the loop filter and applied to low-pass filters in the output circuit. The loop filter output also is applied back to the VCO to complete a phase lock loop. This input changes the VCO and programmed frequency divider output proportionate to the change caused by the carrier input, thus closing the loop to maintain a 90° phase shift between the phase detector inputs.

4-89. The demodulated data output from the loop filter is applied to two filter networks that establish data passband characteristics. Both filter circuits are controlled by Speed Select signal inputs from PCA A4, and provide a flat response over the passband with fast roll-off at the upper band edge. Data output from the filters is applied through an output amplifier and dubbing selector to the OUTPUT BNC connector on the front panel. The output offset selector is used when the recorded data has been placed on tape in an offset mode. The selector jumper is set for the same offset as used in the record mode. The dubbing selector jumper is set to dub position when making a duplicate tape. This function is discussed in paragraph 4-86.

4-90. The record and reproduce data from each FM PCA is applied to Meter Select/Power Detector PCA A5. Pushbuttons on the front of the module are used to select which channel to display on the meter. Then the INPUT (record) or OUTPUT (reproduce) data is selected for meter display by use of a second set of module pushbuttons. The record or reproduce data is then passed to Meter Amplifier/10.5V Regulator PCA A3. Two types of meter display can be selected in the meter amplifier. The first is for the display of DC inputs that are applied directly through an output amplifier to the meter. This form of display is uncalibrated. The second type is a display of peak AC. Input signals are direct coupled through the amplifier section, therefore both AC and DC signals can be displayed in the peak AC position. The input is amplified, rectified and filtered before application to the meter. This form of display is calibrated. Both the DC and PK AC displays available in the module can be used with data recorded and reproduced in the FM PCA's.

4-91. FM FLUTTER COMPENSATION. When a recorder is operated in vibrating environments such as helicopters, cars or ships, flutter can increase during both the record and reproduction process. Flutter is due to the changing velocity of the tape over the record and reproduce heads when the recorder is vibrating, and causes both amplitude and timebase errors. To compensate for amplitude errors, one channel in the recorder may be used for flutter compensation.

4-92. During the record process, no data should be applied to the FM PCA reserved for flutter compensation (Model 3964A channel 2 or 3968A channel 5).

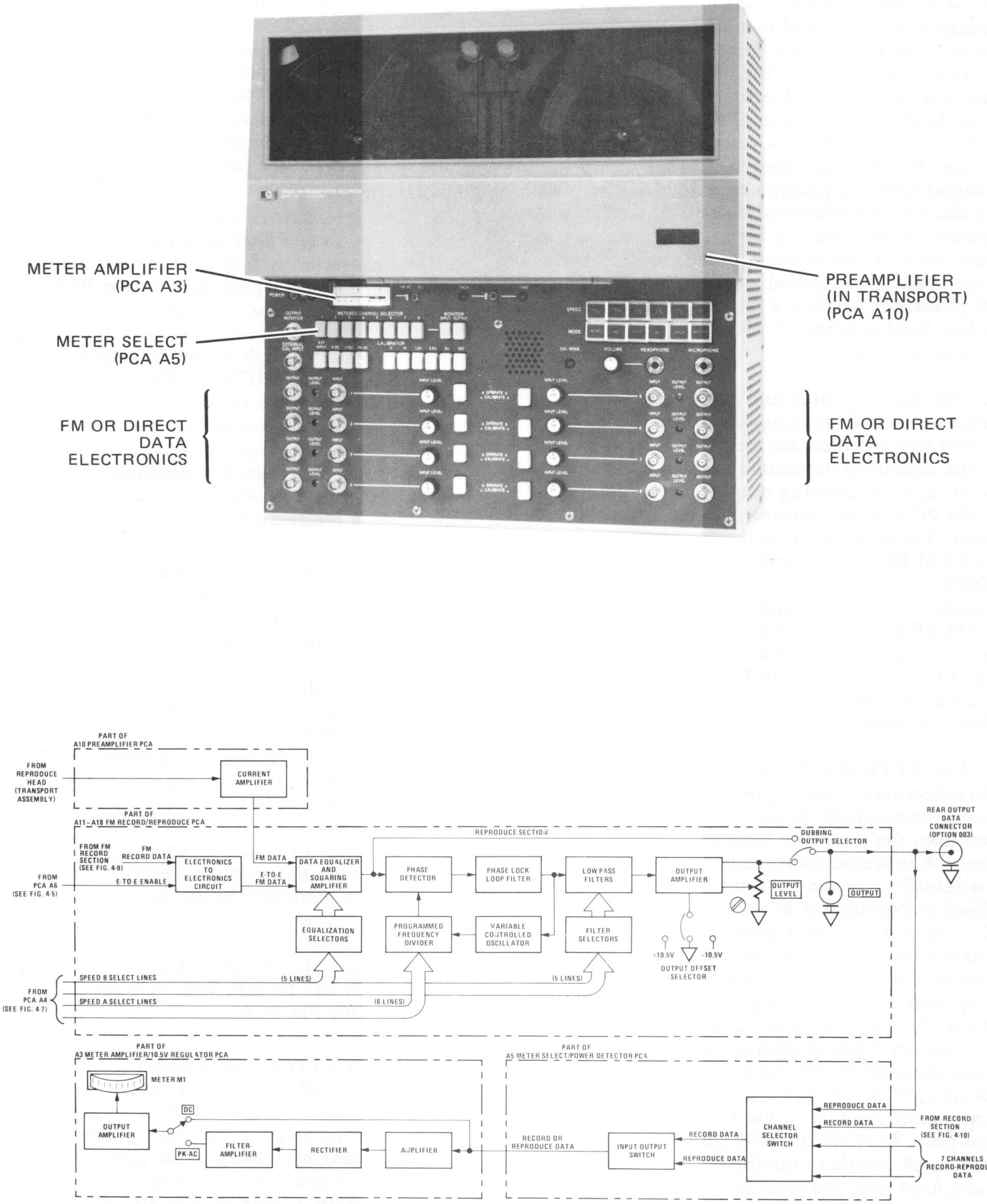


Figure 4-11. FM Reproduce Electronics, Simplified Block Diagram

However, the unmodulated FM carrier from that assembly is placed on tape along with the data modulated FM carriers from the remaining FM assemblies. All recorded carriers then are equally affected by changing tape velocity. During playback, any change in tape velocity across the reproduce heads also cause amplitude and timebase errors. This reproduce flutter also affects all channels equally, including the channel reserved for flutter compensation. The effects of both record and reproduce flutter are summed in the reproduce section of the FM assemblies and applied to the output circuit. The output in the flutter compensation assembly is fed back to the output circuits in the other data assemblies. This feedback cancels the flutter effects in the data PCA's.

4-93. FM Record/Reproduce Channel 2 (PCA A12) in the 3964A and Channel 5 (PCA A15) in the 3968A are wired for use for flutter compensation in the recorders. A simplified illustration of this function is shown in Figure 4-12. During a record operation, the INPUT LEVEL control on the flutter compensating FM Record/Reproduce is turned off (full counterclockwise) and the FLUTTER COMP switch on the recorder rear panel is set to ON. Turning the INPUT LEVEL control off grounds the input circuit in the record section of the amplifier, but removes the ground to the assembly record relay. This ground is replaced by the relay ground supplied by the FLUTTER COMP switch. During the record function, while data is being recorded in the other three assemblies, the unmodulated FM carrier developed in the flutter compensating PCA is recorded on tape track 2 (3964A) or track 5 (3968A).

4-94. During playback, the FM carrier on track 2 (3964A) or track 5 (3968A) is demodulated. The amplitude variations caused by record and reproduce flutter are summed in the reproduce section of the data amplifier and buffered by a unity-gain amplifier. This output is then passed to the FLUTTER COMP switch, which is set to ON. From the switch, flutter compensation signals are applied to an inverting input on output amplifiers in the other assemblies to subtract errors from the output data.

4-95. DIRECT DATA ELECTRONICS.

4-96. The direct data electronics includes both record and reproduce circuits on a single PCA, which can be installed in any one of the data channel positions. A recorder can be equipped with direct record/reproduce PCA's, or any number can be mixed with FM Record/Reproduce PCA's. The following discussion provides a general description of the record and reproduce electronics, with a detailed circuit description included later in this section.

4-97. The record electronics (see Figure 4-13) includes an input amplifier and a bias circuit. Input data is applied to the circuit through an INPUT BNC connector on the front of the module, or from a rear input BNC connector if Option 003 is incorporated. The data is first applied to an OPERATE-CALIBRATOR switch in the input circuit. When the switch is in the CALIBRATE position a calibration voltage is applied to the direct electronics from PCA A7. Both AC and DC voltage can be selected, with AC voltages being used to calibrate the direct electronics. Six input voltage levels are available to make several circuit board adjustments. After calibration, the switch is set to OPERATE and input data is passed through an INPUT LEVEL control to an input amplifier circuit.

4-98. The input amplifier provides a high input impedance and high frequency boost to compensate for record head losses. The amplifier output is passed to the contacts of the record relay through a bias circuit. One portion of the circuit contains a bias trap that isolates the input amplifier and the AC bias input. A second portion of the circuit receives AC bias from a bias

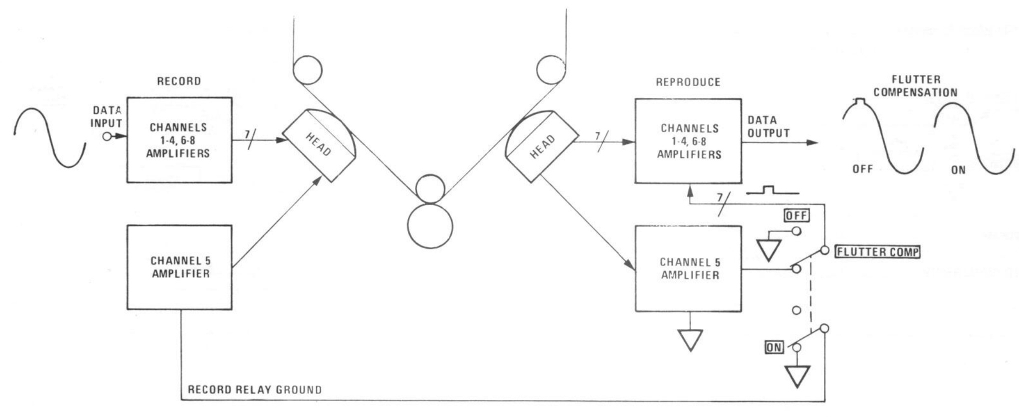


Figure 4-12. 3968A Flutter Compensation Circuit, Simplified Block Diagram

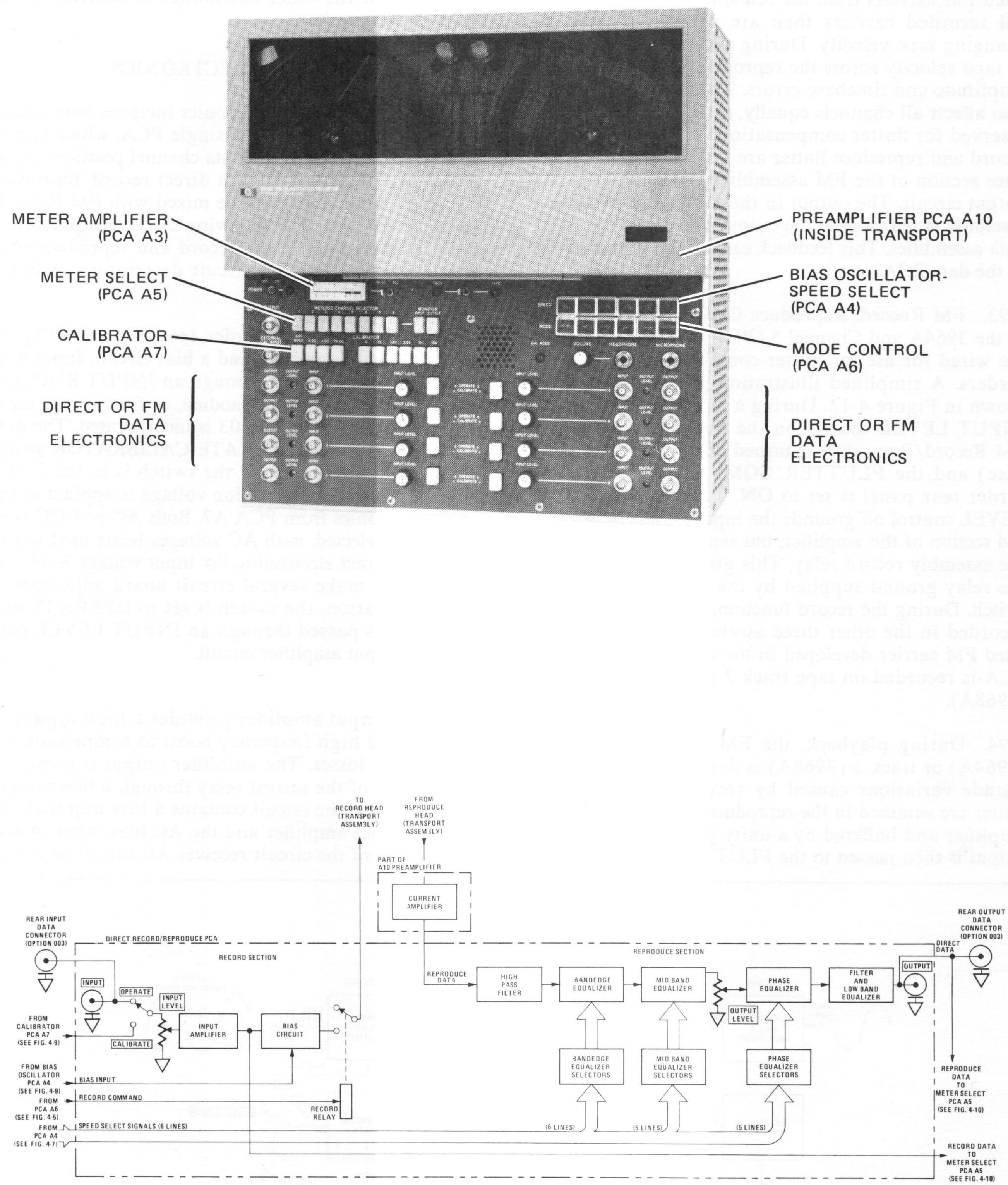


Figure 4-13. Direct Record/Reproduce Electronics, Simplified Block Diagram

oscillator circuit in PCA A4 that is shown in Figure 4-10. The AC bias input is added to the direct data and provides that a minimum distortion occurs during the recording process. A Record Command signal from Mode Control is required to operate the bias oscillator circuit in PCA A4, and to energize the record relay in the direct data PCA's that passes data to the record head. Development of the Record Command signal is through the use of the front-panel RECORD pushbutton, or receipt of an HP-IB or remote control Record Command. Data output from direct PCA's are sent directly to the record head. Data from PCA A14 in the 3964A and PCA A18 in the 3968A is sent to the voice record/reproduce circuit on PCA A8 and then to the record head. During voice record operations, the output line from PCA A14 (3964A) or A18 (3968A) is interrupted and voice data is recorded on the associated track.

4-99. Reproduce data from the reproduce head is first passed through a current sensing amplifier in PCA A10. The Preamplifier PCA is located near the reproduce head in the transport assembly to reduce noise pickup. Data output from the preamplifier is applied to a high-pass filter circuit in the direct PCA. The filter circuit is designed to reject frequencies below 50 Hz for Model 3964A or 100 Hz for 3968A. Data is then passed through two equalizing circuits that provide high and mid frequency boost. Equalizing components in each circuit are changed as tape speed is changed. One of six input speed select signals is active at a time to connect the proper equalizing components into the circuit. The speed select input is generated in PCA A4 by use of a speed pushbutton on the front panel, or by the receipt of a HP-IB or remote speed command.

4-100. Data output from the equalization circuits is applied to a phase equalizer circuit. This circuit also has components changed as type speed is changed, and is used to reduce phase errors between discrete frequencies within the data passband that were caused by the equalization process. The phase equalizer output is filtered through a low-pass network, and then applied through a fixed low-band equalizer that provides low-frequency boost. Output data is taken from the PCA through a front-panel OUTPUT jack, or from a rear-panel BNC connector if Option 003 is installed. Both the input data applied to a PCA and the output data from a PCA are passed to the meter select circuit on PCA A5 and meter amplifier circuit on PCA A3. Simplified illustrations of these circuits are shown in Figure 4-11.

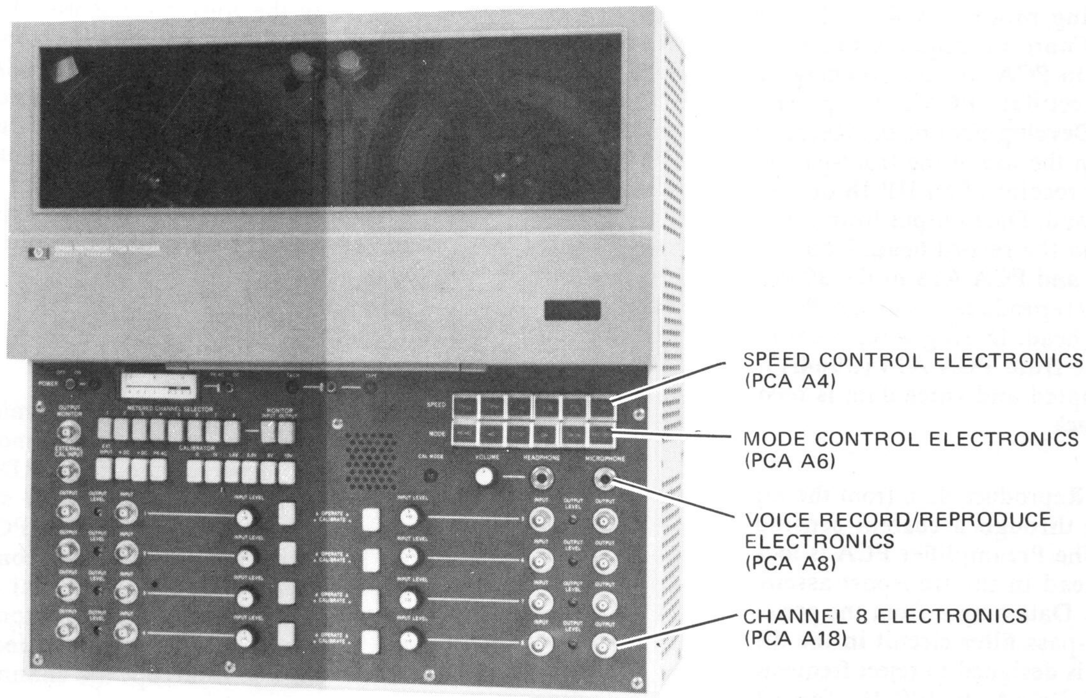
4-101. VOICE ELECTRONICS.

4-102. Voice channel record and reproduce electronics (see Figure 4-14) are located on PCA A8 with the servo loop electronics. Tape track 4 in the 3964A and track 8 in the 3968A is used for recording in the following modes: FM or direct data recording; voice recording; or voice interrupt during an FM or direct operation. When the voice track is used for FM or direct data recording, the record data is received from either PCA A14 (3964A) or PCA A18 (3968A) and applied to the record relay in PCA A8. The Record Command signal output from PCA A6 is active during this function, and record relay A24K4 on the Interconnect PCA is energized. However, record relay K1 in PCA A8 remains de-energized since no ground exists at the relay. The record data is passed to the record head for entry on the tape track.

4-103. To make a voice recording, a microphone is installed in the jack on the front of the module and the > (forward) or < (reverse) and RECORD pushbutton on Mode Control PCA A6 are pressed simultaneously. The Record Command signal from PCA A6 is again active to energize relay K4 on Interconnect PCA A24 and send a Record Command signal to relay K1 in PCA A8. When the push-to-talk button on the microphone is pressed, a ground is applied to relay K1, which energizes to interrupt the channel 4 data from PCA A14.

4-104. Voice input from the microphone is first passed through a preamplifier that provides a high impedance input and boost to higher frequencies. The signals are then passed to an amplifier and a record head driver that provides correct drive to the record head. The bias input is the AC bias used with the FM and direct PCA's to record in such a manner that a minimum of distortion occurs when the data is reproduced. The bias circuit also contains a trap that isolates the amplification circuits from the AC bias input circuit. Automatic gain control is used in a feedback circuit to regulate overall gain of the voice record circuit. When recording, a speaker-ground input from record relay A24K4 is removed to disable the speaker and prevent acoustical feedback.

4-105. Reproduce data is first passed through a current amplifier in Preamplifier PCA A10, and then applied to an equalizer amplifier in PCA A8. At tape speeds of 15 ips and 7-1/2 ips the amplifier provides unity gain. The four lower tape speeds require high frequency boost, and capacitance is added to the circuit for each speed by equalizer selector. These selectors are activated by speed select signals from PCA A4. The voice signals are then passed through a gain amplifier and power amplifier to the headphone jack and speaker. When the unit is not in a record mode, the speaker is active with a ground applied from the record relay on Interconnect PCA A24. Inserting the headphone plug automatically disconnects the speaker input.



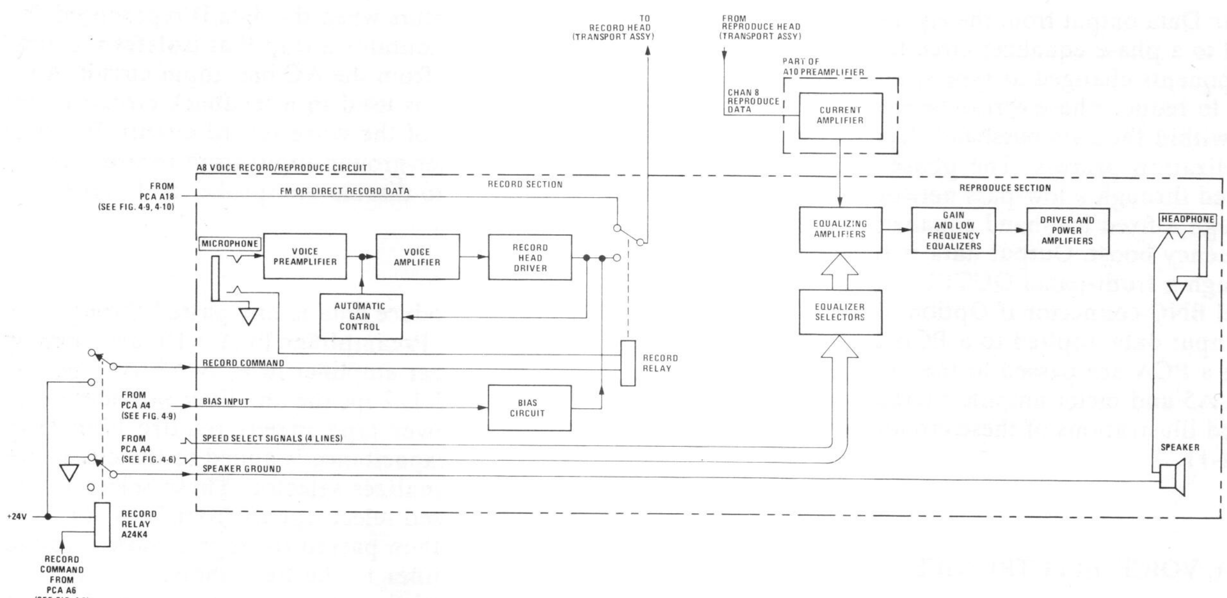


Figure 4-14. Voice Record/Reproduce Electronics, Simplified Block Diagram

4-106. RECORDER POWER SOURCES.

4-107. The recorder contains nine DC voltage sources that are as follows:

Regulated — +24V	Regulated — +10.5V
Unregulated — +16V	Regulated — -10.5V
Unregulated — -16V	Regulated — +5V (A)
Unregulated — +11V	Regulated — +5V (B)
Unregulated — -11V	

4-108. The regulated +24 Vdc supply is developed from rectifier A24CR1 and a filter circuit on Interconnect PCA A24 and solid-state regulator U1 on the chassis. The voltage is used to operate three reel motor control relays, a record command relay on PCA A24, and record relays in all data modules. The unregulated +16 Vdc supply is developed from rectifier CR2 on the chassis and a filter network on PCA A24. The supply is used to develop the regulated +10.5V supply, and is used for operating voltage in PCA A4, PCA A6, PCA A7, and PCA A8. The unregulated -16 Vdc is developed from rectifier CR2 on the chassis and a filter network on Interconnect PCA A24. The supply is used to develop the regulated -10.5V supply, and is used for operating voltages in PCA A4, PCA A6, PCA A7 and PCA A8.

4-109. The unregulated +11 Vdc and -11 Vdc supplies are developed from rectifier CR1 on the chassis and a filter network on Interconnect PCA A24. The +11 Vdc supply is used to develop the regulated +5V (A) and +5V (B) supplies, and is used to develop operating voltage for the HP-IB electronics. Both the +11 Vdc and -11 Vdc power sources are used by servo amplifier drivers in PCA A2 and in the reel motor circuits in PCA A2 and on Interconnect PCA A24.

4-110. The regulated +10.5 Vdc and -10.5 Vdc are developed in Meter Amplifier/10.5V Regulator PCA A3 (see Figure 4-15). Both supplies contain conventional voltage regulating circuits with current limiters. The +5 Vdc (A) power source is developed on +5V Regulator PCA A1 that is also identified in Figure 4-15. The supply contains a voltage regulator, current limiter and over-voltage protection. This +5 Vdc supply is used to operate circuits in data modules A11 through A14. The +5 Vdc (B) power source is developed on Regulator PCA A2, which is identified in Figure 4-15. This supply is identical to the +5V (A) circuit, and is used to operate TTL circuits in PCA A3, PCA A4, PCA A5, PCA A6, PCA A7, and PCA A8.

4-111. OVERLAP ELECTRONICS (OPTION 070).

4-112. The overlap option (see Figure 4-16) is used to extend recording time by connecting recorders in tandem, and starting the second recorder when the first recorder becomes low on tape. The overlap electronics includes Overlap PCA A9, which is installed on an unused portion of Meter Select/Power Detector PCA A5, and a light source and photo transistor that is located on the transport assembly with a STOP-OFF-REWIND switch.

4-113. A free-running multivibrator on PCA A9 in the first recorder generates a square wave output that pulses the light source on the transport assembly, and is applied to a one-shot in the output line from the photo-transistor. The recorder is set to forward-record by pressing the > (forward) and RECORD pushbuttons simultaneously, which provides an overlap enable signal to PCA A9 to enable the output circuit. The light source and photo-transistor are positioned so that when the supply reel of tape (left reel in forward mode) is nearly empty, the pulses of light emitted by the source are received at the photo transistor. These pulses are detected and amplified, and applied to the one-shot circuit. When coincidence occurs between the multivibrator and photo transistor outputs, the one-shot toggles and applies a pulse through a buffer amplifier — threshold detector circuit to the output buffers.

4-114. With the Overlap Enable signal active from PCA A6, a Forward Command and Record Command are applied to Mode Control PCA A6 in the following recorder. The input commands set the logic for forward and record, and the instrument starts recording the data connected to its data channel modules. If the recorder is also configured for overlap operation with a third recorder, the Overlap Enable signal becomes active and is sent to PCA A9 in the second recorder.

4-115. The output pulse from the one-shot in PCA A9 in the first recorder is also applied to a variable delay circuit. This circuit provides an adjustable delay to control the stop or rewind function, and is enabled after time-out of the delay circuit. The output pulse is applied so the STOP-OFF-REWIND switch that functions as follows: In the STOP position, the pulse is applied to the run-stop logic, which stops the recorder immediately. In the REWIND position, the pulse is applied to forward-reverse logic and slow-fast logic to place the recorder in fast reverse. This causes the tape to run in a reverse mode until the take-up reel is empty. In the OFF position, the mode control logic receives no command and the tape runs forward until the supply reel is empty. At the end of a stop, rewind or off function, the first recorder stops and the Overlap Enable signal to PCA A9 is terminated.

4-116. HP-IB INTERFACE ELECTRONICS (OPTION 007).

4-117. The HP-IB electronics is optional equipment that is used to control a recorder's mode and speed from a remote controller. A typical HP-IB installation is shown in Figure 4-17. A bus permits bi-directional

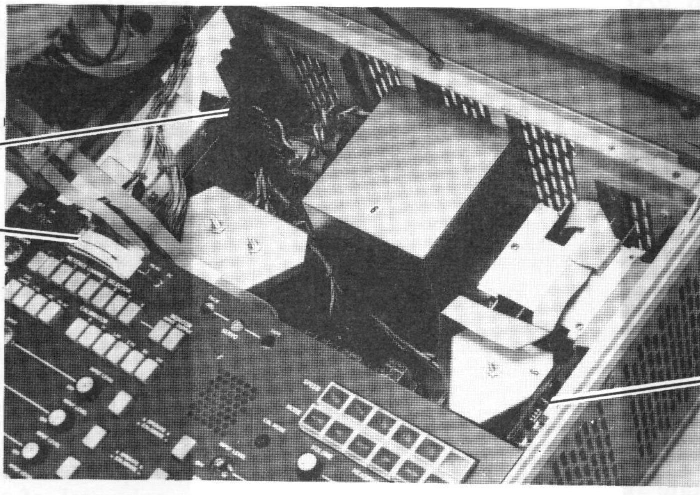


Figure 4-15. Regulated Power Supply Identification

communication between multiple instruments. The interface system consists of a set of sixteen lines which are used to carry data and control information between the interconnected devices. The bus structure is organized into three sets of signal lines:

Data bus – 8 signal lines

Data transfer control – 3 signal lines

Interface management – 5 signal lines

4-118. The data bus carries 8-bit data or control words in bit parallel, byte serial form. These words are transmitted bi-directionally and asynchronously. The three transfer control lines, or "handshake" lines are used to control the transfer of information on the data bus. These lines are identified as follows:

Data Valid (DAV) – Used to indicate that valid information is available on the data lines.

Ready For Data (RFD) – Used to indicate the readiness of a device to accept information.

Data Accepted (DAC) – Used to indicate the acceptance of information by a recipient.

4-119. The five interface management lines are used to provide an orderly flow of information across the interface bus. In operation of the Model 3964A/3968A with an interface bus the REN and EOI lines are not used. The five lines are identified as follows:

Attention (ATN) – Used to identify the nature of the information on the data bus. In the Model 3964A/3968A, data bus information is either an address or control word.

Service Request (SRQ) – Used to indicate that a device needs attention.

Interface Clear (IFC) – Used to place the system in a known quiescent state.

Remote Enable (REN) – Used to enable instruments to go into remote control. Not used by the Model 3964A/3968A.

End or Identify (EOI) – Used to indicate the end of a multiple byte transfer sequence or, in conjunction with ATN, to execute a parallel status polling sequence. Not used by the Model 3964A/3968A.

4-120. Interfacing between the controller bus and HP-IB electronics in the Model 3964A/3968A (see Figure 4-18) is through Interconnect PCA A22. Additional units used in the HP-IB operation are Interface PCA A19, Listen Control PCA A20 and Talk Control PCA A21. Interfacing between the recorder electronics and HP-IB units is through Interface PCA A19.

4-121. Initially when power is applied to the recorder, a Low Power On Preset signal is applied through PCA A19 to Listen Control PCA A20 and Talk Control PCA A21. This input is used to clear flip flops in both units and set the interface in a quiescent condition for operation with the controller. The state of the DAC

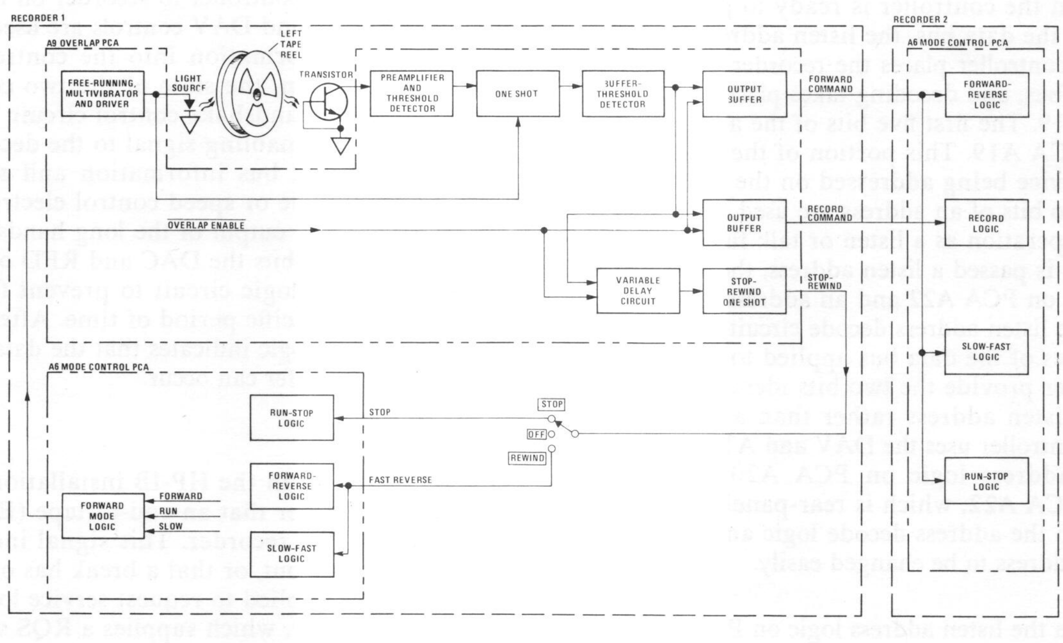


Figure 4-16. Overlap Electronics (Option 070), Simplified Block Diagram

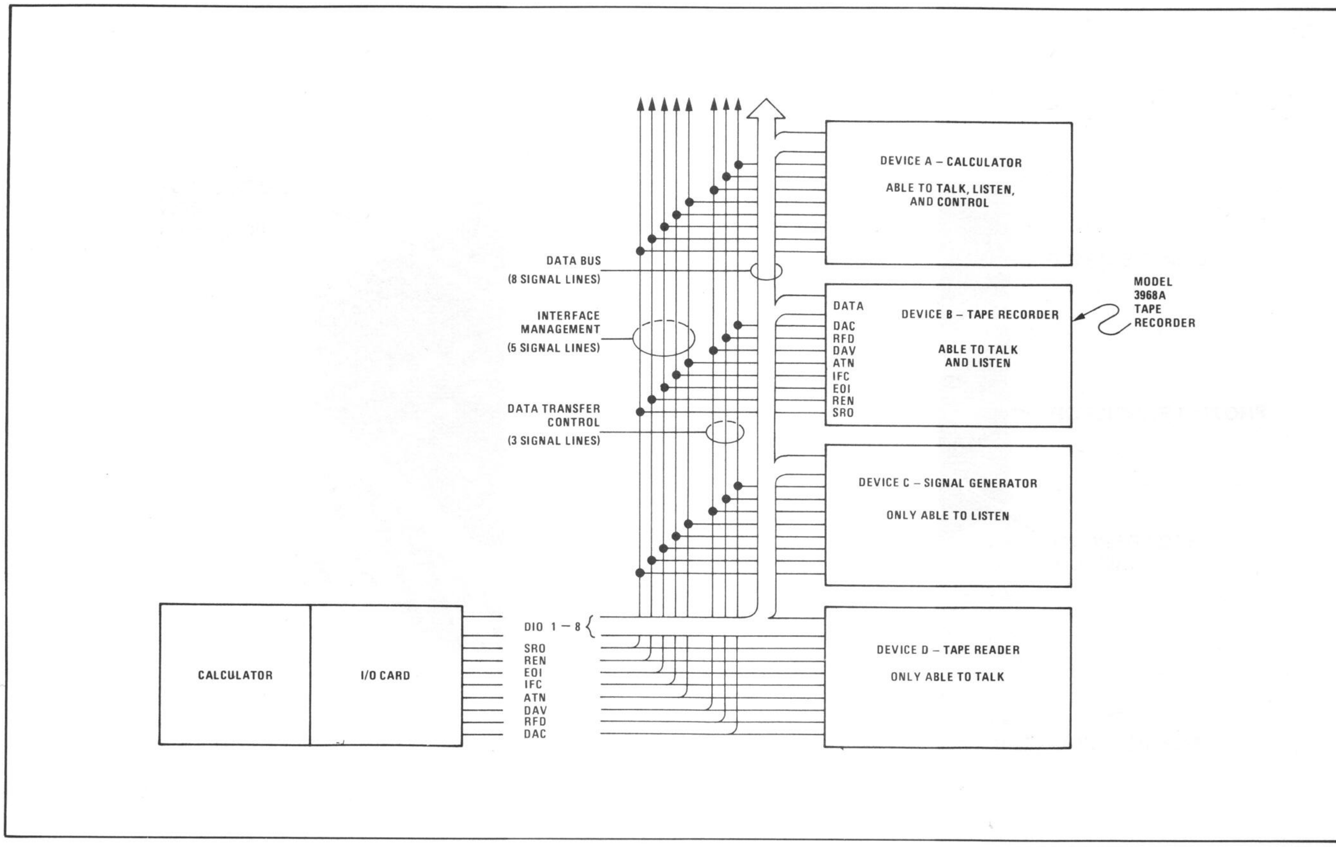


Figure 4-17. Typical HP-IB System Installation

and RFD lines to the controller indicate this idle condition.

4-122. When the controller is ready to pass a control message on the data bus, the listen address logic must be set. The controller places the recorder listen address on the data bus, and decoding takes place on PCA A22 and PCA A19. The first five bits of the address are decoded on PCA A19. This portion of the address indicates the device being addressed on the interface bus. The next two bits of an address are used to identify the upcoming operation as a listen or talk function. When the recorder is passed a listen address, the first five bits are decoded on PCA A22 and an address enable signal is sent to the listen address decode circuit on PCA A19. The two lines of the data bus applied to the listen address decoder provide the two bits identifying the address as a listen address rather than a talk address. Now, the controller uses the DAV and ATN lines to set the listen address logic on PCA A20. An address switch on PCA A22, which is rear-panel accessible, is connected to the address decode logic and permits the recorder's address to be changed easily.

4-123. When the listen address logic on PCA A20 is set in response to an address transfer, the output strobes a short handshake circuit. This circuit sets the listen status logic so that the DAC and RFD lines indicate the address has been received. One output of the listen address logic is applied to a control word decoder on PCA A19. The decoder is used to decode and supply mode or speed commands to the recorder. After the listen address logic has been sent, a control word can be transferred from controller to recorder on the data bus. Again, the ATN and DAV controls are used to transfer the data bus information into the control word decoder. In addition, the state of the two control lines strobe the long handshake control circuit. This circuit provides a final enabling signal to the decoder, which decodes the data bus information and supplies the command to mode or speed control electronics in the recorder. Another output of the long handshake circuit on PCA A20 inhibits the DAC and RFD outputs from the listen status logic circuit to prevent further data transfer for a specific period of time. After the delay, the listen status logic indicates that the data is received and another transfer can occur.

4-124. Talk logic in the HP-IB installation is used to notify the recorder that an end-of-tape (EOT) condition exists in the recorder. This signal indicates that the tape has run out, or that a break has occurred. An EOT signal is applied to request service logic on Talk Control PCA A21, which supplies a RQS signal to the controller, and an enabling input to identification logic also located on PCA A21. As shown in Figure 4-16, the controller is connected to a number of devices on the bus, therefore cannot identify which device is making the service request. To make device identification,

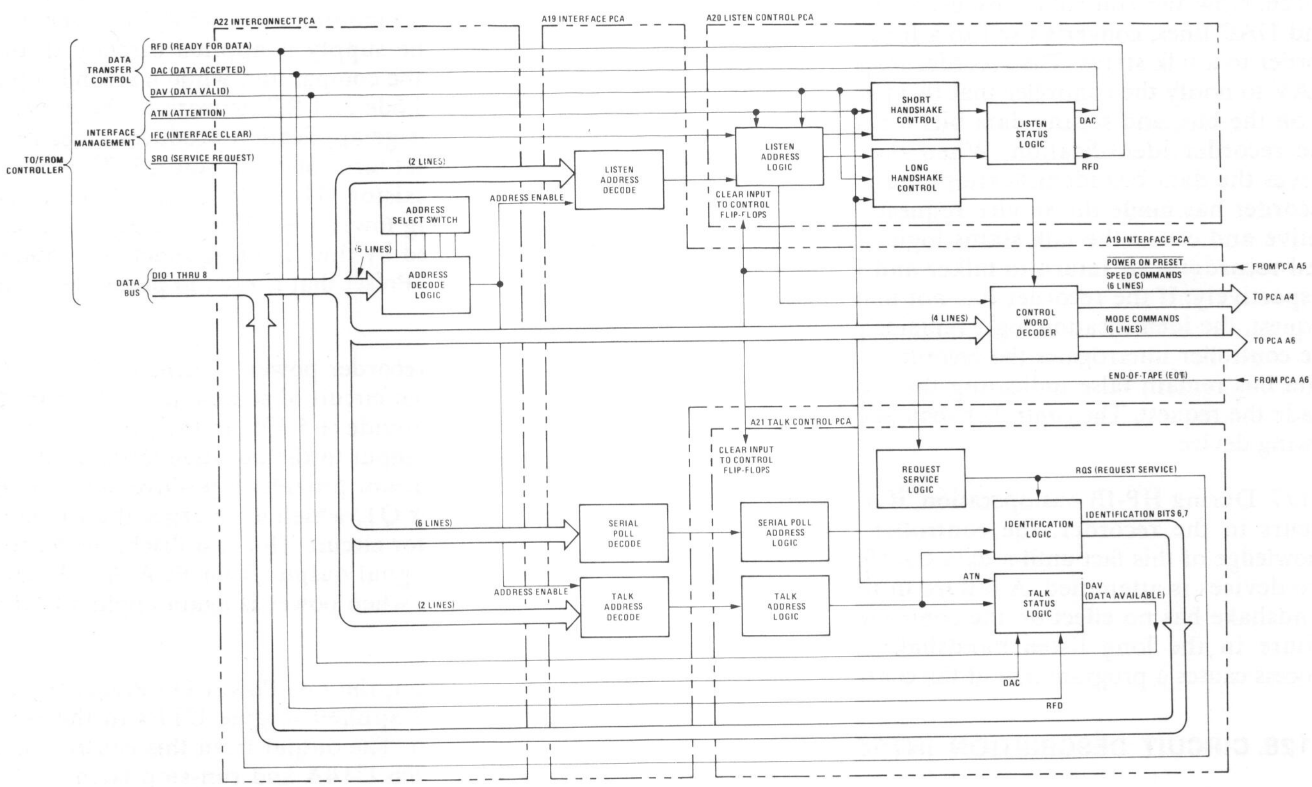


Figure 4-18. HP-IB Electronics (Option 007), Simplified Block Diagram

the controller performs a serial poll of the device connected on the bus. This function is performed by enabling the serial poll address logic simultaneously in all devices connected to the bus, and then addressing each device separately to establish whether the device has made a service request. As each device is polled, it responds by making all lines on the data bus false if it is not requesting service or supplying an identification code on the data bus if it is making a request. In the latter circumstance, the controller becomes a listener and the recorder a talker.

4-125. When the recorder makes RQS active, the controller responds by placing the serial poll enable message on the data bus. This message is decoded by a serial poll decode circuit on PCA A19 which, in turn, sets the serial poll address logic on PCA A21. The serial poll address logic applies a second enabling signal to the identification logic on PCA A21. A controller now addresses each device on the bus individually. When the recorder is addressed, the data bus information is decoded by the address decode logic on PCA A22 and talk address decode logic on PCA A19. The decode circuits provide an enabling input to talk address logic on PCA A21. When the talk address logic is set, one output provides the final enabling signal to the identification logic. A second output is applied to the talk status logic that provides DAV information to the controller.

4-126. Now the controller, by use of the ATN, RFD and DAC lines, converts itself to a listener and the recorder to a talk status. The recorder responds by using DAV to notify the controller that its identification code is on the bus, and setting data bits 6 and 7 which are the recorder identification. When the controller receives the data bus identification, indicating that the recorder has made the service request, DAC is made active and clears the talk status logic. The controller and recorder now return to talker and listener status respectively. If the recorder has not made the service request, the identification logic remains passive. When the controller interrogates the recorder, all lines on the data bus remain false indicating the recorder has not made the request. The controller then addresses the following device.

4-127. During HP-IB bus operation, if a power failure occurs in the recorder, the controller will have no knowledge of this fact until a data transfer between the two devices is attempted. A failure in the short listen handshake has no effect on the controller, however, a failure in the long listen handshake or serial poll process causes a program halt at the controller.

4-128. CIRCUIT DESCRIPTION INTRODUCTION.

4-129. This portion of the principles of operation provides detailed circuit descriptions of the recorder electronics. Each discussion has been arranged to describe a complete recorder function in it's entirety rather than describing the operation of individual circuit assemblies. The functional areas covered are as follows: mode control circuits, speed control circuits, the capstan servo control circuit, FM record/reproduce electronics, direct record/reproduce electronics, voice record/reproduce electronics, power supplies, the overlap function (Option 070) and the HP-IB function (Option 007). Each discussion use servicing block diagrams, which are located in Section VII, to describe signal flow. More detailed circuit descriptions, when necessary, will be referenced to circuit assembly schematic diagrams also located in Section VII.

4-130. POWER ON PRESET DESCRIPTION.

4-131. Meter Select/Power Detector PCA A5 (see Figures 7-16 and 7-20) contains a power sensing circuit that provides a preset signal to logic circuits on Speed Control PCA A4, Mode Control PCA A6, servo control and calibrator logic on PCA A7, and HP-IB circuits on PCA A19, A20 and A21. When power is first applied to the recorder, or reapplied after removal, a low power on Preset signal from PCA A5 is applied to the aforementioned assemblies, and sets the logic to a known quiescent state. This low output continues for approximately 250 milliseconds and then the signal goes high to enable other circuits in the recorder electronics.

4-132. When power is applied to the recorder, comparator U1 on PCA A5 monitors the +5V(B) power supply. One leg of the supply is applied directly to the negative input of the comparator, while a second input passes through a diode and RC network to the positive terminal. This voltage application produces a negative output from U1 that turns off transistor Q1. The collector circuit of transistor Q1 contains an RC network that starts charging toward +5 Vdc. The 250 millisecond delay provided by this charging function supplies the low Power On Preset that is used to preset the logic circuits.

4-133. When the recorder power is turned off, the RC network in the input circuit of comparator U1 on PCA A5 continues to provide +5 Vdc to the positive input after the +5V(B) input to the negative terminal is removed. The comparator provides a positive output that turns on transistor Q1, which discharges the RC network in the collector circuit. This fast discharge terminates the power signal output from PCA A5. A new preset cycle occurs when power is again applied to the recorder.

4-134. After turn on, the low Power On Preset signal in PCA A6 is first applied to gate U11B in the run-stop control circuit. The output from this control gate clears fast-slow latch U14A and run-stop latch U14B in preparation for an upcoming operation. After 250 milliseconds when the Power On Preset signal goes high, power detector Q16 is turned on and enables the brake and pinchroller relay driver circuits. In the event

of a power failure, transistor Q16 turns off, the pinchroller is pulled out and the reel motor brake applied automatically.

4-135. The Power On Preset signal applied to Speed Control PCA A4 sets gate U114B and turns on transistor Q102. This condition applies a ground to the 3-3/4 ips Speed Select line into priority encoder U101. This input sets the logic in PCA A4 so that the recorder automatically presets to a speed of 3-3/4 ips. In PCA A7, the Power On Preset signal performs two functions. The signal applied to power detector U15B in the servo control circuit inhibits capstan motor operation until the turn-on delay is completed. The signal applied to synthesizer U3 in the calibrator circuit resets the device so that its count starts at zero after time out. Both of these circuits are described later in this section.

4-136. The Power On Preset signal applied to Interface PCA A19 is used to preset logic in the HP-IB electronics. The input is used to clear a listen address flip flop and preset a listen status flip flop. The latter circuit provides an indication to the remote controller that the recorder is on-line in an idle state. The preset signal also is applied to Talk Control PCA A21 and clears all flip flop associated with the HP-IB talk function.

4-137. MODE CONTROL CIRCUIT DESCRIPTION.

4-138. Most of the mode control electronics are located on Mode Control PCA A6 (see Figure 7-22), with control relays located on Interconnect PCA A24 and in the transport section of the recorder. These circuits and the associated relays control the run-stop, forward-reverse, fast forward, fast reverse and record functions of the recorder. The control logic for the EOT (end-of-tape) and E-to-E (electronics-to-electronics) are also located on PCA A6. The following discussion describes the control input circuits; forward, reverse and record circuits; reel motor circuits; mode transition circuits; EOT operation; and E-to-E control.

4-139. MODE CONTROL INPUT CIRCUITS.

4-140. Motion of the recording tape (see Figure 7-15) can be controlled from three locations; a remote control unit (supplied by the user); a remote controller, such as a calculator, through the HP-IB electronics in the recorder; or from the front panel. Control and status lines between the recorder and remote control unit (see Figure 2-6 for a typical installation) is through rear-panel connector J2 and buffer gates on Mode Control PCA A6. The HP-IB control lines are connected directly to PCA A6, thus, no buffering is required.

4-141. Front panel control of the recorder is dependent upon the state of an Inhibit signal that is generated on Tape Speed Control/Bias Oscillator PCA A4. Normally, the Inhibit signal is high and is inverted through buffer gates on PCA A6 before being applied to the mode pushbutton controls. Pressing a pushbutton then provides a low pulse to the control logic. Likewise, the control signals from either a remote control unit or the HP-IB electronics are low pulses. When a remote-control operation is to be conducted, making the Remote Inhibit line to PCA A4 low causes the Inhibit line to PCA A6 to go low. This signal condition locks out the front-panel mode controls on PCA A6 and the speed controls on PCA A4.

4-142. FORWARD MODE CONTROL.

4-143. Forward motion of the tape (see Figure 7-15) is initiated by pressing the front-panel > (forward) pushbutton, or receiving a forward signal from a remote control unit or the HP-IB electronics. Any one of these inputs are passed through control gate U6B to set the forward/reverse latch to forward (U8B-4 high). The same input command is passed through control gate U6C to clear fast/slow latch U14A (Q low, $\overline{Q}$ high), and through control gate U11A to clock run/stop latch U14B (Q high, $\overline{Q}$ low). A summary of mode control functions that occur during a forward operation is as follows:

Run Command (high) sent to PCA A7:	Enables the capstan motor control circuit.
Pinchroller solenoid drivers on:	Pulls pinchroller in.
Brake solenoid drivers on:	Sets brake off.
Stop delay relay drivers off:	No effect.
Run/Stop relay driver on:	Reel motor control relay K3 energized.
Fast/Slow relay driver off:	Reel motor control relay K2 deenergized.
Reverse/forward relay driver off:	Reel motor control relay K1 deenergized.
Forward Command (high) sent to PCA A7:	Sets the capstan motor circuit to move tape in the forward direction.
Forward Selected (low) sent to connector J2:	Indicates forward mode selected to a remote control unit.
Overlap Enable (low) sent to overlap electronics:	Enables the overlap circuits (Option 070 only).

4-144. The high run output from run/stop latch U14B is sent to record control logic (refer to paragraph 4-160), gate U7C in the pinchroller-brake enable circuits, and to gate U12C in the forward lamp circuit. Operation of gate U7C is controlled by an input from motion latch U9B, the input from a mode transfer delay timer, and the Run signal. Normally, the $\overline{Q}$ output of motion latch U9B is high. When the recorder is in a fast mode and a slow mode is selected, or a stop condition occurs, the motion latch is preset and the $\overline{Q}$ output goes low and inhibits gate U7C. The motion latch output remains low until the capstan motor is stopped when the Capstan Stopped input from PCA A7 goes low. This input clears the motion latch and again provides a high at gate U7C. The motion transfer delay timer is used to inhibit gate U7C for a period of time after a fast-to-slow or run-to-stop transition occurs. During either of these transitions, the timer output goes low and remains low for approximately 1.5 seconds. This time delay permits capstan motor response to the new command at the input circuit. When all inputs at gate U7C are high, the gate is enabled and provides the following circuit activity.

4-145. One output from gate U7C is inverted through gate U19F and is sent to servo-control logic on PCA A7 as a Run Command. This high signal, which is accompanied by a Forward Command from the forward/reverse latch, enables the capstan motor circuit. As the capstan motor starts into motion, the Capstan Stopped signal from PCA A7 to PCA A6 goes high, however, has no effect on the mode-control logic at this time.

4-146. The output from gate U7C also is applied to gate U8D that controls operation of the pinchroller solenoid in the recorder transport section, and through gates U19E and U19F to the brake relay drivers. As discussed previously, fast/slow latch U14A is set to Slow, and the output Slow signal is high. After inversion through gate U8D, the low Slow signal is combined with the low output from gate U7C to turn on the pinchroller relay drivers. Initially, current drivers Q7, Q12 and Q4 are used to energize the pinchroller solenoid through the -16 Vdc supply. Transistor Q3 is a holding device to keep the solenoid energized and the pinchroller in, with minimum power dissipation.

4-147. The low output from gate U7C is inverted through gates U19E and U19F, and is used to turn on current drivers Q6, Q11, Q2 and holding transistor Q1 in the brake solenoid holding circuit. The energized state of the two solenoids release the brakes as the capstan motor starts to move, and applies pinchroller pressure to move the tape. The high output from gate U19F also provides the previously described Run signal to PCA A7, and is used to turn on run/stop relay driver Q8. This transistor, in turn, energizes reel motor control relay K3 on Interconnect PCA A24. The reel motor circuit is described later in this section. It should be noted that the brake and pinchroller relay drivers are connected to power-down detector Q16 (see Figure 7-16). In the event of a power loss, transistor Q16 turns off thereby disabling both sets of drivers. This action deenergizes the pinchroller and brake solenoids.

4-148. During a forward mode of operation, the Slow output from fast/slow latch U14A is applied to the record control and E-to-E mode logic (refer to paragraphs 4-160 and 4-169). The Slow output also is combined with the high Run and Forward signals at gate U12C to light the > (Forward) lamp. One Slow output is inverted through gate U5B and applied to slow/fast relay driver Q9. This low input to transistor Q9 has no effect, and reel motor control relay K2 on Interconnect PCA A24 remains deenergized during a forward-mode operation. A second output of gate U5B is directed to the pinchroller control gate U8D, and provides the circuit activity described in the preceding paragraph.

4-149. The forward/reverse latch provides a high Forward output from gate U8B-4 that is sent from PCA A6 to the servo control logic on PCA A7. This signal is used by the Capstan Direction Detector, which provides direction information to the capstan motor control circuit. The signal in PCA A7 is also used by a detector circuit that inhibits the reference frequency input to the capstan motor control logic when switching between forward, reverse and stop.

4-150. The high Forward output from gate U8B-4 also is combined with the previously described Run and Slow signals at gate U12C to light the lamp in the > (Forward) pushbutton. Gate U12C also provides a low output that is sent to the remote control connector for use as a status indication in a remote control unit. A second low output (Overlap Enable) is supplied to the overlap electronics in an Option 070 instrument.

4-151. REEL MOTOR FORWARD OPERATION.

4-152. Relays K1, K2 and K3 on Interconnect PCA A24 control operation of the left and right reel motors (see Figure 7-17). In the forward-slow mode, relays K1 and K2 are deenergized and relay K3 is energized. These states are established by the forward mode control logic on PCA A6, as discussed in the foregoing paragraphs. Both the left and right reel motors are driven by a 11 Vdc supply through the K1, K2, K3 relay matrix to a 2 amp (1.2 amp and .8 amp) current source on PCA A2.

4-153. In the forward mode, the relay matrix connects right reel motor B3 to the 2 amp source with a polarity that causes the motor to rotate clockwise. The relay matrix also connects the left reel motor B2 to the 1.2 amp source, with a polarity that causes the motor to rotate counterclockwise with no tape loaded. When tape is loaded, the right reel motor B3 becomes dominant in the circuit with 2 amps flowing as opposed to the 1.2 amps flowing through motor B2. This condition

causes both reels to rotate clockwise (tape motion left-to-right). The reverse 1.2 amp current flow through reel motor B2 causes that device to attempt to rotate counterclockwise, thus providing hold-back tape tension and the correct tape-to-head pressure for data transfer.

4-154. REVERSE MODE CONTROL.

4-155. Reverse motion of the tape (right-to-left) is initiated by pressing the front-panel < (reverse) pushbutton, or receiving a reverse signal from the HP-IB Electronics or a remote control unit (see Figure 7-3). The momentary low input is passed through gate U6A and sets the forward/reverse latch U8A/U8B to reverse (U8A-1 high, U8B-4 low). The same momentary low input is passed through gate U6C to clear fast/slow latch U14A (Q low, $\overline{Q}$ high), and through control gate U11A to clock run/stop latch U14B (Q high, $\overline{Q}$ low). A summary of mode control functions that occur in response to a reverse command is as follows:

Run Command (high) sent to PCA A7:	Enables the capstan motor circuit.
Pinchroller drivers Q7, Q12, Q4, Q3 on:	Pinchroller engaged.
Brake drivers Q6, Q11, Q2, Q1 on:	Brake off.
Stop delay driver Q14 off:	No effect.
Run/Stop driver Q8 on:	Reel motor control relay K3 energized.
Reverse/Forward driver Q10 on:	Reel motor control relay K1 energized.
< (Reverse) push-button lamp on:	As indicated.
Reverse Selected signal (low) to remote connector:	Indicates the reverse mode selected.
Overlap Enable (high) overlap electronics:	Prevents overlap operation (Option 070 only).
Forward Command (low) sent to PCA A7:	Sets capstan motor control logic for reverse movement of tape.

4-156. Both the high Run and Slow outputs from latches U14B and U14A provide the same circuit activity as described for the forward mode, with the exception that the Forward Command is now low. This signal condition sets the capstan direction logic in PCA A7 and causes the capstan motor to move the tape in a reverse (right-to-left) direction.

4-157. The two outputs from the forward/reverse latch are reversed from the levels described in the forward mode. The low level from gate U8B-4 inhibits gate U12C causing the Forward Command to go low. The high Reverse signal from gate U8A turns on relay driver Q10, which energizes reverse relay K1 on Interconnect PCA A24. The output of gate U8A also is combined with the high Run and Slow signals at gate U12A to light the < (Reverse) pushbutton lamp. A low output from gate U12A is buffered through gate U17B and applied to connector J2 on Interconnect PCA A24 for remote control use.

4-158. REEL MOTOR REVERSE OPERATION.

4-159. The Run Selected and Reverse Selected outputs from PCA A6 energize relays K1 and K3 on Interconnect PCA A24 (see Figure 7-17). The relay contact closure matrix is shown in Detail B, Figure 7-4. In a reverse configuration, the left reel is for takeup and the right reel for supply. Left reel motor B2 has 2 amps of current flowing and moves in a counterclockwise direction. Right reel motor B3 is connected so that 1.2 amps flows through the device with a polarity that causes the motor to attempt to rotate the reel in a clockwise direction; however, left reel motor B2 dominates in the circuit and the right reel motor provides the necessary hold-back tension.

4-160. RECORD MODE CONTROL.

4-161. Recording can be performed in either the forward or reverse mode, however, the RECORD pushbutton must be pressed simultaneously with the Forward or Reverse pushbutton (see Figure 7-15). Control of the record function is established by the state of record latch U9A and a Servo Phase Lock signal received from PCA A7. A record operation is initiated by pressing either the forward or reverse pushbutton and the RECORD pushbutton, which enables gate U3C to clear latch U9A (Q low). The low output from U9A is inverted through U5C and applied to gate U4C where the Servo Phase lock input from PCA A7 is applied.

4-162. When the capstan servo system is phase-locked, (the capstan motor turning at the selected speed), the Servo Phase Lock signal is high. Enabled gate U4C in PCA A6 turns on record relay driver Q13 which, in turn, energizes record relay K4 on Interconnect PCA A24. The low output from record latch U9A is buffered through gate U17F and passed to rear-panel connector J2 for remote control use. The signal also is inverted through gate U5C and turns on lamp driver Q5 to

light the RECORD pushbutton lamp. Another output from inverter U5C is applied to the E-to-E logic, which is described in paragraph 4-169 and sent to PCA A7 as a Record Selected signal. This high signal is used in PCA A7 to inhibit operation of the tape servo system when recording.

4-163. When record relay K4 on PCA A24 energizes, a +24 Vdc Record Command signal is sent to Tape Speed Control/Bias Oscillator PCA A4, Voice Channel/Servo Loop PCA A8 and to the FM and Direct Record/Reproduce Amplifiers. The Record Command in PCA A4 turns on the bias oscillator, whose output is used in the FM, direct and voice record circuits. This bias function is described in the discussion of these recording circuits. The Record Command applied to PCA A8 is used when the voice record circuit is enabled by pressing the push-to-talk button on the microphone installed in the recorder front-panel jack. This function supplies a ground to one side of record relay A8K1, which energizes when the Record Command is received. The energized relay connects the microphone input signals that are mixed with bias to the channel 8 (channel 4 in the 3964) record head when making a voice recording. During normal operation of the recorder, the microphone pushbutton is not operated, and the record relay remains deenergized for lack of a ground. The relay contacts now connect FM or direct record data to the record head.

4-164. The +24 Vdc Record Command also is applied to relay K1 to the FM and Direct Record/Reproduce Amplifiers. When energized, these relays connect the record section of each amplifier to its associated record head. A ground for the relays is provided by the INPUT LEVEL control on each amplifier. When the control is turned off (full counterclockwise), the ground is removed and the record relay remains deenergized.

4-165. Three conditions can interrupt a record operation through gates U7B and U18C to the preset control of record latch U9A. When changing from forward to reverse or front reverse to forward, the output of gate U13B goes low and presets flip flop U9A. Also, when a fast mode is selected (U14-$\overline{Q}$ low) or run/stop latch U14B is set to stop (U14B-$\overline{Q}$ low), the low is applied to gate U7B and presets the record latch. When the record latch is preset, the RECORD pushbutton and either the forward or reverse pushbutton must be operated to clear the latch and restore the record functions.

4-166. FORWARD-REVERSE MODE TRANSITIONS.

4-167. When the recorder is in a forward or reverse mode and a command is received to go to the opposite mode, control logic interrupts the record function while the capstan motor is reversing direction (see Figure 7-15). On PCA A6, if the recorder is operating in a forward mode, the output of gate U8A is low and the output of gate U8B is high. The output of gate U8A is applied to gate U13C in the forward-reverse record control circuit, which is one of three logic controls that can inhibit a record operation. An incoming reverse command is combined with the low output of gate U8A to turn on gate U13C. The output of gate U13C causes record latch U9A to preset, thus inhibiting the record function. The output of gate U8B in the forward-reverse latch is used to reverse the capstan motor direction. An RC arrangement consisting of resistor R40 and capacitor C33 maintains a high input at gate U8A for approximately 200 milliseconds, after receipt of the reverse command, thus preventing a further change in the state of the forward-reverse latch during the transition period. Gate U13D and the RC network consisting of resistor R41 and capacitor C34 perform the same functions when transferring from reverse to forward.

4-168. A further condition that occurs when switching from forward to reverse is a level change in the Forward Command signal to PCA A7. This transition from high to low is sensed by reverse command detector U17B and capstan direction detector U21B in PCA A7. Detector U17B causes stop control flip flop U15A to provide an output that inhibits a reference frequency to the capstan servo system and slows the capstan motor to a stop. Simultaneously, the low Forward Command signal sets a latch in the Capstan Servo control circuit that reverses the rotation of the capstan motor. After the motor stops, capstan motion detector U10A/U10B clears the stop control flip flop and the reference frequency is restored to the capstan servo system. The capstan motor now moves in a reverse direction and builds up to the selected speed. During this reversal, the Run Command to PCA A7 remains active, and keeps the capstan control circuit enabled during the transition. The tape reel motors are automatically switched over to reverse by relays K1, K2 and K3 on PCA A24 as previously described.

4-169. E-TO-E OPERATION.

4-170. The E-to-E (electronics-to-electronics) function is used when using FM Record/Reproduce Amplifiers to bypass the recorder heads when one of the following events occur: the servo system is out of phase lock; the recorder is in a fast forward or fast reverse mode; and when making an FM recording in the reverse mode. The E-to-E logic on PCA A6 (see Figure 7-15) controls operation of a transistor on each of the FM Record/Reproduce Amplifiers. When the E-to-E Enable output from PCA A6 is low, the transistor on the amplifier PCA's is turned off, and the record section of the amplifier is connected directly to the reproduce section, thus bypassing the record head.

4-171. When the capstan motor is stopped, or during the time that the recorder is changing from one mode to another, the Servo Phase lock signal from PCA A7 to PCA A6 goes low. This input is inverted through gate U5D and produces the low E-to-E Enable output

from PCA A6 that is passed to the FM Record/Reproduce Amplifiers. An E-to-E Enable signal also is generated each time a fast mode is selected. The $\overline{Q}$ output of fast/slow latch U14A is connected to gate U18C in the E-to-E control circuit. When a fast mode is selected, the $\overline{Q}$ output signal from U14A goes low to generate the E-to-E Enable signal through gates U18C and U8C. This function isolates the record head during the entire period of time that the record is in a fast mode. When a reverse record mode of operation is selected, the output of record latch U9A is low. This output is inverted through gate U5C and combined with a Reverse signal input at gate U3A to produce the low E-to-E Enable output through gates U18C and U8C.

4-172. FAST FORWARD MODE CONTROL.

4-173. A fast forward operation can be initiated at the recorder front panel, from a remote control unit, or from a controller through the HP-IB electronics (see Figure 7-16). In any operation, a momentary low is applied through gate U6B to set the forward/reverse latch to forward (U8A low, U8B high), through gate U6D and inverter U19B to preset fast/slow latch U14A (Q high, $\overline{Q}$ low), and through gate U11A to set run/stop latch U14B (Q high, $\overline{Q}$ low). A summary of control functions that occur in fast forward is as follows:

Run Command (high) sent to PCA A7:	Enables the capstan motor circuit.
Pinchroller solenoid drivers Q7, Q12, Q4 Q3 off:	Keeps the pinchroller disengaged.
Brake solenoid drivers Q6, Q11, Q2, Q1 on:	Releases brake.
Stop delay drive off:	No effect.
Fast Mode Selected (high) sent to PCA A7:	Inhibits tape servo reference capability.
Run/Stop driver Q8 on:	Reel motor control relay K3 energized.
Fast/Slow driver Q9 on:	Reel motor control relay K2 energized.
Reverse/Forward driver Q10 off:	Reel motor control relay K1 deenergized.
Forward Command (high) sent to PCA A7:	Sets capstan motor control circuit to move tape forward.
>> (Fast Forward) pushbutton lamp on:	As indicated.
Fast Forward Selected (low) sent to Connector J2.	Indicates the fast forward mode selected.

4-174. Forward/reverse latch U8 is set by a Fast Forward signal to provide a high output at gate U8B and a low output at gate U8A. The output from gate U8B is combined with the high Run and Fast signals at gate U12B to light the >> (fast forward) pushbutton lamp. Another output from gate U12B is sent to the rear-panel, remote-control connector as a Fast Forward Selected signal. A second output from gate U8B is sent to PCA A7 as a Forward Command. This signal is used with the Run Command to set the capstan motor control logic for a forward operation. The low Reverse output from Gate U8A is applied to gate U7A and reverse/forward relay driver Q10. This low signal has no effect in the fast forward mode, and reverse relay K1 on Interconnect PCA A2 remains deenergized.

4-175. Fast/Slow latch U14A is preset by the fast forward input. The high Q output from the latch is applied to gate U3D that operates during fast-to-slow transitions, which are described in paragraph 4-185. The low Slow signal output from the latch is inverted through gate U5B to turn on fast/slow relay driver Q9. The driver, in turn, energizes fast relay K3 on Interconnect PCA A24. A high output from gate U5B is also sent to a tape-mode enable circuit in PCA A7 as a Fast Mode Selected signal. This high input inhibits the tape servo reference control logic during fast forward or fast reverse operation. In any fast mode, another high output of gate U5B is applied to gate U8D in the pinchroller circuit and inhibits pinchroller operation during high speed tape motion. The same output from gate U5B is also applied to gate U12B and lights the fast forward pushbutton lamp.

4-176. Run/stop latch U14B is clocked by the fast forward signal input through gate U11A. The high Run output from the latch is applied to gate U3B in a run-to-stop transition circuit discussed later herein, and combined with the previously described Forward and Fast signals at gate U12B to light the lamp in the fast forward pushbutton. Another Run output from latch U14B is applied to gate U7C in the brake and pinchroller control circuits. During normal fast forward operation, the inverted output of timer U10 and the $\overline{Q}$ output of motion latch U9B are high and gate U7C is enabled. One output of the gate is inverted through U19E to turn on brake solenoid drivers Q6, Q11, Q2 and Q1 and release the brake. A second output of gate U7B is applied to pinchroller control gate U8D, however, the device is inhibited by the high Fast signal at pin 11. This condition keeps the pinchroller solenoid deenergized and the pinchroller out. A third output of gate U7B is inverted through gate U19F and turns on drive Q8 which, in turn, energizes run relay K3 on Interconnect PCA A24. A second high output

from gate U19F is the Run Command signal that is used with the Forward Command signal in PCA A7 to control operation of the capstan motor servo system.

4-177. REEL MOTOR FAST FORWARD OPERATION.

4-178. During a fast forward operation (see Detail A, Figure 7-18) run/stop relay driver Q8 and fast/slow relay driver Q9 are on and energize relays K3 and K2 on Interconnect PCA A24. Reverse relay K1 remains deenergized in the mode. Current flows through reel motors B2 and B3 causing them to rotate clockwise, with the left reel serving as the supply device and the right reel as the takeup unit. A 1-ohm resistor, R6, is connected across supply reel motor B2 to decrease current flow through the motor, thus decreasing drive to the reel. This decreased drive causes a slight drag and prevents tape spillage as the supply reel is unloaded.

4-179. FAST REVERSE MODE CONTROL.

4-180. A fast reverse operation (see Figure 7-16) is initiated at the recorder front panel, from a remote control unit, or from a controller through the HP-IB electronics. At the start of a fast reverse operation, a momentary low is applied through gate U6A to set the forward/reverse latch to reverse (U8A high, U8B low), through gate U6D and inverter U19B to preset fast/slow latch U14A (Q high, $\overline{Q}$ low), and through gate U11A to set run/stop latch U14B (Q high, $\overline{Q}$ low). A summary of control functions that occur in fast reverse is as follows:

Run Command (high) sent to PCA A7:	Enables the capstan motor circuit.
Pinchroller solenoid drivers Q7, Q12, Q4, Q3 off:	Keeps the pinchroller disengaged.
Brake solenoid drivers Q6, Q11, Q2, Q1 on:	Releases brake.
Stop delay driver off:	No effect.
Fast Mode Selected (high) sent to PCA A7:	Inhibits tape servo reference capability.
Run/Stop relay driver Q8 on:	Reel motor control relay K3 energized.
Fast/Slow driver Q9 on:	Reel motor control relay K2 energized.
Reverse/Forward relay driver Q10 on:	Reel motor control relay K1 energized.
Forward Command (low) sent to PCA A7:	Sets capstan motor control circuit to move tape in reverse.
<< (Fast Reverse) pushbutton lamp on:	As indicated.
Fast Reverse Selected (low) sent to connector J2:	Indicates fast reverse mode selected.

4-181. Operation of mode control logic in a fast reverse mode is essentially the same as described for the fast forward mode, excepting the state of the forward/reverse latch. In fast reverse, the high reverse output from gate U8A is combined with a high output from the fast/slow latch and the run/stop latch to light the fast reverse pushbutton lamp. A second low output from gate U7A is buffered through gate U17E and passed to remote control connector J2 for use with a remote control unit. The high reverse output from gate U8A also turns on reverse/forward relay driver Q10 to energize reverse relay K1 on Interconnect PCA A24.

4-182. Gate U8B in the forward/reverse latch provides the Forward Command output that is sent to PCA A7 for control of the capstan motor servo system. In a fast reverse mode this Forward Command output is low and is sensed by the reverse command detector in PCA A7. The detector output causes the capstan motor to stop and start motion in the reverse direction. Circuit action in PCA A7 during a change to fast reverse is the same as changing to a reverse mode.

4-183. REEL MOTOR FAST REVERSE OPERATION.

4-184. During a fast reverse operation (see Figure 7-18) reverse/forward relay K1, fast/slow relay K2, and run/stop relay K3 are energized. The relay contact closure configuration is shown in Detail B, Figure 7-18. In the fast reverse configuration, the left reel serves as the takeup device and the right reel as supply. Reel motors B2 and B3 now rotate counterclockwise, with resistor R6 connected across supply reel motor B3 to provide the required drag to prevent tape spillage as the reel unloads.

4-185. FAST-TO-SLOW CONTROL TRANSITION.

4-186. Delay provisions are included in mode control logic to allow the capstan motor and brake circuits to cycle from a fast forward or fast reverse mode to stop and then go to a slow speed mode. When the recorder is in a fast mode, fast/slow latch U14A is preset with the Q output high and the $\overline{Q}$ output low (see Figure 7-16). A forward or reverse command clears the latch through gate U13A causing the latch to change state, and applies a high from gate U6C to one side of gate U3D. Despite the change of state in latch U14A, the

Fast signal to gate U3D remains high for approximately 200 milliseconds due to the RC network consisting of resistor R11 and capacitor C26. The output of gate U3D toggles 1.5 second timer U10 and 200 millisecond timer U20 through gates U4D and U5E to start each timer through its cycle.

4-187. A second output from gate U3D is combined with the high Capstan Stopped signal from PCA A7 at gate U4B to preset motion latch U9B. The $\overline{Q}$ output from the latch goes low to inhibit gate U7C in the pinchroller and brake circuits, thus keeping the pinchroller out and applying the brake. A further output from gate U7C makes the Run Command to PCA A7 low and turns off run/stop relay driver Q8. The output of timer U20 becomes high when the output from gate U5E goes low, and turns on stop delay relay driver Q14. This action keeps run relay K3 energized for approximately 200 milliseconds after relay driver Q8 is turned off to keep power on the reel motors and maintain tape tension while the brakes are being applied.

4-188. The low Run Command to PCA A7 is sensed by the stop control circuit in that assembly. One output of this circuit inhibits the reference frequency to the servo motor phase-lock logic, and a second output inhibits the capstan motor drive circuit. When the capstan motor stops, the Capstan Stopped signal in PCA A7 goes low to clear the stop control logic in PCA A7 and motion latch U9B in PCA A6. The output of U7C remains high, however, since U10 is in its timing cycle and keeps gate U7C inhibited. After 1.5 seconds, U10 times out to provide a high to gate U7B which becomes active. The Run Command to PCA A7 goes high to enable the capstan drive circuit, the brake is released as drivers Q6, Q11, Q2 and Q1 turn on, and one side of gate U8D in the pinchroller circuit is enabled. In a slow forward or reverse mode, the other side of gate U8D is low and solenoid drivers Q7, Q12, Q4 and Q3 are on to pull in the pinchroller. This completes the fast-to-slow cycle and recorder operation proceeds in the slow mode.

4-189. RUN-TO-STOP TRANSITIONS.

4-190. Delay provisions are also included in mode control logic to sequence the capstan motor, brake and pinchroller activity when a stop condition occurs. A recorder stop is controlled by gate U11B in the run/stop latch circuit (see Figure 7-16) with four conditions controlling the stop function: receipt of a Stop Command from the front panel, from a remote control unit, or from the HP-IB electronics or receipt of an EOT (End-of-Tape) signal from the EOT delay circuit on PCA A6. The low Power On Preset signal at gate U11B is used to clear latches U14A at the start of an operation, and has no further effect when the signal goes high (refer to paragraph 4-130).

4-191. When gate U11B is toggled by one of the input signals, its output is applied to three circuits. One output is passed through gate U13A and clears fast/slow latch U14A, and sets the recorder into the slow mode. A second output from gate U11B is inverted and clears run/stop latch U14B. The same low output is passed through gate U4A and is combined with the high Capstan Stopped signal to preset motion latch U9B, which inhibits gate U7C and provides the same circuit activity as described in paragraph 4-187. During a stop sequence, run/stop latch U14B changes state when cleared; however, the Run signal is held high by the RC network consisting of resistor R12 and capacitor C27. This high output is combined with the third output of gate U11B to toggle gate U3B, whose output is passed through gate U4D to start timers U10 and U20 through a timing cycle. These timers perform the same circuit functions that occur during a fast-to-slow transition.

4-192. The Stop signal output from run/stop latch U14B is applied to gate U18A in the pushbutton lamp circuit. When no EOT condition exists, pin 1 of gate U18A is high and the gate becomes active with receipt of the Stop signal. The STOP pushbutton lamp lights and a low Stop Selected signal is passed to remote control connector J2. When an EOT condition exists the STOP pushbutton is not lighted, however, all other stop conditions are fulfilled as discussed in the following paragraph.

4-193. END-OF-TAPE CIRCUIT OPERATION.

4-194. The EOT circuit in PCA A6 (see Figure 7-16) consists of one-shot U15 and gate U18B that are connected to microswitches located in the transport assembly. Each switch is operated by a tension arm in the tape path and, with the tape loaded, provide a low input to U15. This low input is also applied to one side of gate U18B which contains a delay RC network consisting of resistor R8 and capacitor C25. With normal tape tension, the output of one-shot U15 is high, however, the low EOT signal input from the end-of-tape switches the output from gate U18B high.

4-195. Three circumstances can produce an EOT condition: if tape is not loaded; if the tape runs out; or if the tape breaks. In each instance, the tension arms move up and a high is applied to U15 and to the delay circuit in gate U18B. With a high input, the output of one-shot U15 goes low and remains low for approximately 1.5 seconds. During the same period of time the RC network is charging to provide a high on the other side of gate U18B. After U15 times out, it's output goes high to turn on gate U18B, which provides a low Delayed End-of-Tape Signal. The delay in signal development is to allow time for tension arm motion to dampen after mode control changes, thus preventing transients from triggering a recorder stop condition.

4-196. One low Delayed End-of-Tape output from gate U18B is passed to rear panel connector J2 for use with a remote control unit. A second low Delayed End-of-Tape signal is passed to the service request circuit in the HP-IB electronics, and is used to indicate to the controller that an End-of-Tape condition exists in the recorder. A third output from gate U18B is applied to gate U18A in the STOP pushbutton lamp circuit. When there is an active Delayed End-of-Tape signal, gate U18A is inhibited and the STOP lamp is off. In this manner, a recorder stop can be attributed to an initiated stop (STOP lamp on), or one that is due to an EOT condition (STOP lamp off).

4-197. TAPE SPEED CONTROL CIRCUIT DESCRIPTION.

4-198. Tape speed in the forward and reverse play modes is a product of capstan motor rotation and is under control of Tape Speed PCA A4. The capstan motor, which is a DC device, operates in a phase-lock system using frequency and phase comparison between two frequencies to establish motor speed. A reference frequency is supplied to the phase-lock system under control of the speed commands developed in PCA A4. The second frequency is developed by a capstan motor tachometer. The basic frequency is initially supplied to the circuit and the motor starts to turn, thus generating the tachometer frequency. The two frequencies are compared until the tachometer frequency is the same as the basic frequency when phase lock occurs. The motor continues to rotate the tape at the selected speed until phase lock is broken, as would be the case in changing speeds or motor direction. The following discussion describes power on preset, front-panel control, HP-IB interface controls, remote control, speed control lines, and speed indicators. Servicing block diagram Figure 7-12, is used to support this discussion, and schematic diagram Figure 7-14 can be used for detailed circuit analysis.

4-199. PRESET DESCRIPTION.

4-200. Recorder tape speed operations are started when power is applied to the instrument. A power detector circuit on PCA A5 provides a low Power On Preset signal that is used in the recorder to preset selected circuits. Application of the preset signal to the power detector circuit in PCA A4 provides a low output from transistor Q102 to input pin 11 of priority encoder U101, whose functions are listed in Table 4-1. The priority encoder is used in the speed select circuit to prevent erroneous speeds being selected by more than one speed button being pressed at the same time. The last speed selected will provide the resultant tape speed. With the 3-3/4 ips speed line low on input pin 11, encoder U101 provides a binary 0,1,1 on output pins 9,7 and 6, which are connected to bistable latch U102.

4-201. A fourth output from pin 14 of encoder U101 is applied to a delay enable circuit consisting of one-shots U113A and U113B connected in series. The first one-shot is toggled by the low encoder output and starts a 20 millisecond timing cycle. After time set, the negative-going Q output of one-shot U113A toggles one-shot U113B. This causes the $\overline{Q}$ output of U113B to go low, and provides an enable pulse to latch U102. The binary 0,1,1 output from the encoder is then clocked through the three D-type latches in U102 to the input circuit of speed select decoder U103, whose functions are listed in Table 4-2. The delay provided by one-shot U113A is intended to counteract both the activation and release switch bounce inherent in mechanical switch operation. The binary 0,1,1 input to decoder U103 causes a low output at pin 7, which is the 3-3/4 ips speed line. Then when power is applied to the recorder, a tape speed of 3-3/4 inches per second is automatically selected.

4-202. CONTROL FUNCTIONS.

4-203. Recorder tape speed can be controlled from three locations: from the front panel, from a remote controller through the recorder HP-IB Electronics, or from a remote control unit through Interconnect PCA connector A24J2, which is accessible on the recorder rear panel. Both a remote control unit and necessary interconnecting cabling are supplied by the user.

4-204. The front panel controls are non-latching, momentary contact pushbutton types that are physically located on PCA A4 and protrude through the recorder front panel. Each pushbutton is equipped with a lamp that is lighted when the associated circuit is in operation. On both the servicing block diagrams and schematics, the pushbuttons and lamp are illustrated separately for circuit clarity. The pushbutton control circuit is enabled by an inhibit circuit consisting of gates U105D and U114A. This inhibit circuit normally provides a high to six inverters on PCA A4 which, in turn, provide a low to one side of each of the speed-control pushbuttons. When the switch is operated, a low is applied to priority encoder U101 and causes the same circuit activity as described for power on preset.

4-205. When a remote control unit is being used with the recorder, the remote inhibit line that attaches to connector A24J2-15 should be made low. This low is inverted through the inhibit circuit, and causes a high output from the inverters on PCA A4. This high on the front-panel pushbuttons lock out these controls during remote operation. The remote speed control inputs at connector A24J2, which parallel the front panel lines in PCA A4, are made low to be active and cause the same encoder, latch and decoder activity as previously described. Complete wiring details and a description of each control and status line is contained in Section II.

4-206. To operate the recorder with an HP-IB interface, a remote controller and interconnecting cabling is

Table 4-1. Speed Select Encoder Functions

SPEED SELECTED	ENABLE PIN	INPUT PINS						OUTPUT PINS			DELAY ENABLE PIN
	5	1	12	11	2	13	4	9	7	6	14
15 ips	0	0	X	X	1	X	1	1	1	0	0
7-1/2 ips	0	1	0	X	1	1	1	1	0	1	0
3-3/4 ips	0	1	1	0	1	1	1	0	1	1	0
1-7/8 ips	0	X	X	X	0	X	1	0	1	0	0
15/16 ips	0	1	X	X	1	0	1	0	0	1	0
15/32 ips	0	1	1	1	1	1	0	0	0	0	0
1 = TRUE = 2.5V 0 = FALSE = 0V X = IRRELEVANT											

Table 4-2. Speed Select Decoder Functions

ENABLE PIN	INPUT PINS			OUTPUT PINS						SPEED SELECTED
12	15	14	13	4	6	7	3	5	1	
0	1	1	0	0	1	1	1	1	1	15 ips
0	1	0	1	1	0	1	1	1	1	7-1/2 ips
0	0	1	1	1	1	0	1	1	1	3-3/4 ips
0	0	1	0	1	1	1	0	1	1	1-7/8 ips
0	0	0	1	1	1	1	1	0	1	15/16 ips
0	0	0	0	1	1	1	1	1	0	15/32 ips
1 = TRUE = 2.5V 0 = FALSE = 0V										

required. This is an optional installation (Option 007) and the interconnecting details are also listed in Section II, Installation. The remote controller passes both speed and mode control characters to a decoder on the interface PCA A19 under controlled conditions. The decoder on PCA A19 makes one signal line low to PCA A4 in response to a character input from the controller. The speed control lines from the HP-IB electronics also parallel the front panel and the remote control lines, and, additionally, provide the same encoding and decoding activity previously described. No provisions are included for an inhibit capability in the HP-IB interface parameters. Therefore, the front panel pushbuttons are in the circuit during the HP-IB operations. Care should be taken to insure that the front-panel pushbuttons are not used during HP-IB operations. A detailed discussion of the development of HP-IB speed commands is contained in paragraph 4-400.

4-207. SPEED A CONTROL LINES (TTL).

4-208. Six lines carry the Speed A control signals from PCA A4 to Calibrator/Servo Control PCA A7 and to the FM Record/Reproduce PCA's. In PCA A7 the Speed A control lines are applied to a programmed divider consisting of divider U23 and divide-by-two flip flop U21A. This circuit provides the internal reference frequency to the capstan motor servo system. An oscillator developed base frequency of 54 kHz (50 kHz with IRIG Option 041) is applied to the divider circuit. Each low Speed A select signal applied causes a proportionate division of this input frequency. Final output frequencies from the divider range from 27 kHz (25 kHz Option 041) with the 15 ips Speed A signal active to 843.75 Hz (781.25 Hz Option 041) when 15/32 ips Speed A is low. This internal reference signal is then applied to the servo system in PCA A8, and is discussed in paragraph 4-220.

4-209. In the FM Record/Reproduce PCA's, all Speed A signals are applied to programmable frequency divider U4 in the record section and divider U10 in the reproduce section. Divider U4 operates in conjunction with a voltage controlled oscillator to provide FM carrier frequencies appropriate for each speed. Reproduce divider U10 similarly operates with a second voltage controlled oscillator as part of the demodulation process. Both dividers operate with the Speed A control signals in the same manner as the servo system divider U23/U21A in PCA A7.

4-210. SPEED B CONTROL LINES (±10 VDC).

4-211. A second group of speed control lines, which are defined as Speed B lines, are connected between PCA A4 and Voice Channel/Servo Loop PCA A8, and between PCA A4 and the FM and Direct Record/Reproduce PCA's. In PCA A8, the voice reproduce data is equalized at the four lowest tape speeds from 3-3/4 ips to 15/32 ips. Each Speed B select signal turns on a FET switch that connects additional capacitance and resistance into the circuit as tape speed decreases. A further discussion of the voice circuit is contained in paragraph 4-336.

4-212. In the FM and Direct Record/Reproduce PCA's, the Speed B control signals are used in the reproduce electronics of each amplifier. The signals turn on FET switches, which control equalization and filter characteristics of the reproduce data in the FM modules. In Direct Record/Reproduce PCA's, the Speed B control signals also turn on FET switches that add capacitance and resistance to the equalization circuits. Detailed discussions of the FM Electronics are contained in paragraph 4-274 and the direct electronics in paragraph 4-322.

4-213. LAMP AND REMOTE CONTROL LINES (TTL).

4-214. Each output line from speed select decoder U103 in PCA A4 is passed to lamp drivers U106A through 106F. These drivers are turned on by a low, and provide a low to one side of the speed pushbutton lamps. When a speed is selected, the low through the associated driver turns on the lamp, which has approximately +24 Vdc on the other side. When the pushbutton is released, the lamp remains lighted due to the latched output of decoder U103. One set of speed output lines from decoder U103 is passed through output buffers U116A through U116F and totem-pole type resistor network R103 to rear panel connector A24J2. This output buffering provides correct negative-true, TTL signal levels for use in a remote control unit.

4-215. SERVO CONTROL AND SERVO LOOP CIRCUIT DESCRIPTION.

4-216. The servo control circuit is located on Calibrator/Servo Control PCA A7 and the servo loop circuit is located on Voice Channel/Servo Loop PCA A8. Both circuits are illustrated on servicing block diagram Figure 7-23 and schematic diagram 7-25. The servo circuits control operation of the capstan motor that moves the recording tape in the forward and reverse modes. In addition the servo circuits provide status indications to other recorder circuits. The following discussion includes descriptions of the power on preset circuit, internal reference frequency development, capstan motor control circuit, capstan direction control, tachometer frequency generation, servo phase lock, capstan motor operation, 15/32 ips speed operation, capstan motion detection, forward-reverse transitions, capstan stop operation, tape reference operation, and external reference frequency operation.

4-217. PRESET FUNCTION.

4-218. When power is applied to the recorder, a power detector circuit in Power Detector PCA A5 provides a low Power On Preset signal that is used in the recorder to preset essential circuits. This Power On Preset remains low for approximately 250 milliseconds after power is applied. The signal presets power down detector A7U15B whose output inhibits gate U22B in the capstan motor on/off control circuit. The output of the control circuit causes capstan control drivers Q209 and Q208 to turn on and provide a high Capstan Motor On Signal to the power amplifier control gates.

4-219. When the Capstan Motor On signal is high, diode CR108 in the FET Q102 circuit is back biased and FET Q102 is on. In the power amplifier control circuit, diode CR107 is forward biased and FET Q104 is off and disconnects drive to power amplifier driver U103. This condition ensures that the Capstan motor is stopped before drive is applied after a power-down condition.

4-220. INTERNAL REFERENCE FREQUENCY DEVELOPMENT.

4-221. The low Power On Preset signal also sets Tape Speed Control PCA A4 for 3-3/4 ips speed. The Speed Control PCA provides a high state 3-3/4 ips Speed A signal to programmed divider U23 in Servo Control PCA A7 which develops the internal reference frequency. A crystal-controlled oscillator consisting of transistors Q201, Q202 and crystal Y1 provides an output frequency of 108 kHz (100 kHz if Option 041 is installed). The output frequency is divided by two in D-flop U6B then applied to programmed divider U23, and to a divide-by-100 circuit that is used to detect capstan motion.

4-222. When an active speed command from PCA A4 is applied to programmed divider U23, a divide function occurs as shown in Table 4-3. The divide functions that occur when IRIG servo reference frequency Option 041 is installed are listed in Table 4-4. One divider output is passed through a low pass filter network

consisting of inverter U19B, resistor R26, coil L206 and capacitor C220 to the INTERNAL SERVO REF OUTPUT jack on the recorder rear panel. This output is used when recording a tape reference signal, and is described later in this discussion. Another divider output is passed to test point TP2 on Servo Loop PCA A8 to provide a convenient point of test during maintenance periods. A third output is passed to a 15/32 ips speed selector circuit that includes gates U16D and U24. At all speeds except 15/32 ips, the selector circuit output is the same as the output of divide-by-two flip flop U21A. The internal reference frequency is passed to a reference frequency selector consisting of gates U105A, U105B and U105C in PCA A8. These selector gates provide selection of either the internal reference frequency or an externally supplied reference frequency.

4-223. When a speed of 15/32 ips is selected in PCA A4, Speed A input to PCA A7 is active. This signal causes a normal divide function to occur in divider U23. The input select signal is applied to gate U24 in the reference frequency selector circuit, and causes divider output to be sent directly to PCA A8 rather than passing through flip flop U21A. Reference frequency during 15/32 ips operation is 1.69 kHz not 845 Hz. See paragraph 4-249 for twice the internal reference frequency use during 15/32 ips operation.

4-224. CAPSTAN MOTOR CONTROL CIRCUIT.

4-225. A Run Command from Mode Control PCA A6 places the servo system into operation. The high Run Command is passed through connector P2-A on PCA A7 and applied to the clock input of stop control flip

Table 4-3. Programmed Dividers U23/U21A Functions (Standard)

SPEED	STROBE PIN	ENABLE PIN	INPUT PINS						FUNCTION	U23 OUTPUT	U21A OUTPUT
	10	11	13	3	2	15	14	1			
15 ips	0	0	1	1	0	0	0	0	---	54 kHz	27 kHz
7-1/2 ips	0	0	0	1	0	0	0	0	÷ 2	27 kHz	13.5 kHz
3-3/4 ips	0	0	0	0	1	0	0	0	÷ 4	13.5 kHz	6.75 kHz
1-7/8 ips	0	0	0	0	0	1	0	0	÷ 8	6.75 kHz	3.375 kHz
15/16 ips	0	0	0	0	0	0	1	0	÷ 16	3.38 kHz	1.69 kHz
15/32 ips	0	0	0	0	0	0	0	1	÷ 32	1.69 kHz	845 Hz

Table 4-4. Programmed Dividers U23/U21A Functions (Option 041)

SPEED	STROBE PIN	ENABLE PIN	INPUT PINS						FUNCTION	U23 OUTPUT	U21A OUTPUT
	10	11	13	3	2	15	14	1			
15 ips	0	0	1	1	0	0	0	0	---	50 kHz	25 kHz
7-1/2 ips	0	0	0	1	0	0	0	0	÷ 2	25 kHz	12.5 kHz
3-3/4 ips	0	0	0	0	1	0	0	0	÷ 4	12.5 kHz	6.25 kHz
1-7/8 ips	0	0	0	0	0	1	0	0	÷ 8	6.25 kHz	3.125 kHz
15/16 ips	0	0	0	0	0	0	1	0	÷ 16	3.125 kHz	1.5625 kHz
15/32 ips	0	0	0	0	0	0	0	1	÷ 32	1.5625 kHz	781 Hz

flop U15A, and to stop control gate U7B. The low-to-high transition of the Run Command signal has no effect on flip flop U15A at this time. The command applied to gate U7B is inverted and passed to gate U22B that controls the capstan motor on/off circuit.

4-226. Gate U22B has an output from external reference control gate U7A and power detector U15B applied. The output from gate U7A is low except when the recorder is operated using an external reference frequency and the reference frequency input is removed. When the tachometer frequency goes below 540 Hz, the Capstan Stopped signal from flip flop U110B is low. This low clears power detector U15B which supplies a low to turn on gate U22B. The output of gate U22B is inverted through gate U16E in the control circuit and turns off capstan control driver Q209-Q208. The latter circuit provides a low Capstan Motor On signal to power amplifier control transistors Q104 and Q102 in PCA A8. The low input turns on FET Q104 and turns off FET Q102, thus connecting the servo loop electronics to power amplifier driver U103.

4-227. CAPSTAN DIRECTION CONTROL.

4-228. Simultaneously with the development of the Run Command signal in PCA A6, the level of the Forward Command output from PCA A6 is also established. If a forward mode is selected this output is high, and if a reverse mode is selected the signal is low. In PCA A7, the forward command input is applied to forward and reverse detector one-shots U17A and U17B, and to capstan direction detector U21B. One-shots U17A and U17B are used to detect a transition from forward to reverse, or reverse to forward and are described later in this discussion.

4-229. Operation of the capstan direction detector U21B is dependent upon the state of the input Forward Command and the level of the Capstan Stopped output from motion detector flip flop U10B. When the Forward Command is high (forward motion selected) and the Capstan is stopped (output from U10B low), capstan direction detector U21B provides a high Forward/Reverse Control output. When the Forward Command input is low (reverse motion selected) and the capstan is stopped, a low Forward/Reverse Control output is provided by U21B. After capstan motion has started, the output of detector U10B goes high to inhibit operation of the clock circuit at U21B.

4-230. TACHOMETER FREQUENCY DEVELOPMENT.

4-231. The internal reference frequency developed in PCA A7 is applied to internal-external reference frequency selector U105 in PCA A8. With the rear panel selector switch set to internal, the External Reference Enable signal input to PCA A8 is high to enable gate U105C. The enabled gate passes the internal reference frequency through one-shot U113 to one side of the servo phase lock circuit. When the recorder first turned on the tachometer frequency is applied to the opposite side of the phase lock circuit and the two outputs from the phase detector circuit are unbalanced. This unbalanced level into forward-reverse selector U107 causes an output that is a logic 0 (approximately 140 mV) in the forward mode, a logic 1 (approximately 3.5V) in the reverse mode.

4-232. The output from selector U107 is transferred through low pass filter U104 and power amplifier control FET Q104 to power amplifier driver U103. Capstan motor drive is then passed through drivers in Motor Supply PCA A2 to capstan motor B1 in the transport assembly. A more detailed discussion of this capstan motor circuit is presented later in this discussion. As the capstan motor starts to turn, a mechanically linked tachometer disc also starts to rotate. The disc has lines that permit light from a light source to illuminate a photo transistor. The disc, light source, and photo transistor are all part of the capstan assembly and are not field repairable.

4-233. As the capstan motor turns in response to capstan drive, a frequency is developed by the tachometer that is proportional to capstan motor speed. This tachometer frequency is fed back to the input of PCA A8 where it is filtered and passed to shaper U101. The output of the shaper is a square wave that is passed to tach-tape frequency selector U106. In a tachometer mode the Tape Mode Selected signal from PCA A7 is high, and gate U106C in the selector circuit is turned on. The tachometer frequency is then passed through gate U106D to one-shots U112 and U116 which are used for pulse shaping. One-shot U116 is used as a shaper at all speeds, and one-shot U112 is used only when a 15/32 ips speed is selected. Both one-shots are used at this low speed to provide a frequency doubling function that is described in paragraph 4-253. The tachometer frequency output from the one-shot is passed to the servo phase lock circuit that has the internal reference frequency on one side and the tachometer frequency on the other.

4-234. SERVO PHASE LOCK.

4-235. The servo phase lock circuit and its associated timing are illustrated in Figure 4-19. The circuit has two modes of operation: the first is the frequency mode that occurs during capstan motor acceleration or deceleration (tach frequency greater or less than the reference frequency); and the second is the phase mode that occurs when phase lock exists (tach frequency equal to the reference frequency). The first sequence in the timing diagram illustrates the frequency mode when the reference frequency is greater than the tachometer frequency. Frequency difference is sensed by gate U108A in the off-frequency detector circuit, and clears phase-lock flip flop U109A through gate U110B. The cleared condition of U109A produces a low Q output from flip

flop U109B, and sends a Servo Phase Locked signal to PCA A7.

4-236. The Servo Phase Locked input to PCA A7 is applied to a servo phase lock detector circuit where transistors Q205 and Q206 sense the state of flip flop U109B in PCA A8. In the out-of-lock state, the output of Q206 is low. This low output from the detector circuit inhibits tach-tape mode lock gate U20A and U20B keeping the front-panel TACH and TAPE lamps off. A low Servo Phase Lock signal is also sent to PCA A6 indicating that the servo system is out of phase lock.

4-237. The output circuit in the phase lock loop assumes a steady state after the second successive reference frequency pulse and makes no further change. In this state, the Q output of flip flop U120A is high and the $\overline{Q}$ output is low. These two outputs are applied to forward-reverse selector gate U107 whose output is determined by the state of the forward-reverse control from PCA A7. In the forward mode, the control signal is high. The signal is applied directly to selector gate U107C and inverted through gate U107B for application to selector gate U107A. The outputs from flip flop U120A are combined with these levels at gates U107A and U107C to provide a low output at gate U107D. When the recorder is in a reverse mode, the forward-reverse control signal is low which is inverted through gate U107B and applied directly to gate U107C. When combined with the outputs from Flip-Flop U117A, a high output is generated by gate U107D. Table 4-5 lists the outputs at gate U107D during various states of the servo phase lock circuit.

4-238. The output from the forward-reverse selector is passed through low-pass filter U104 to the input circuit of power amplifier control FET Q104. This point is used to sum the feedback from the capstan motor, the forward-reverse bias control and the output from filter

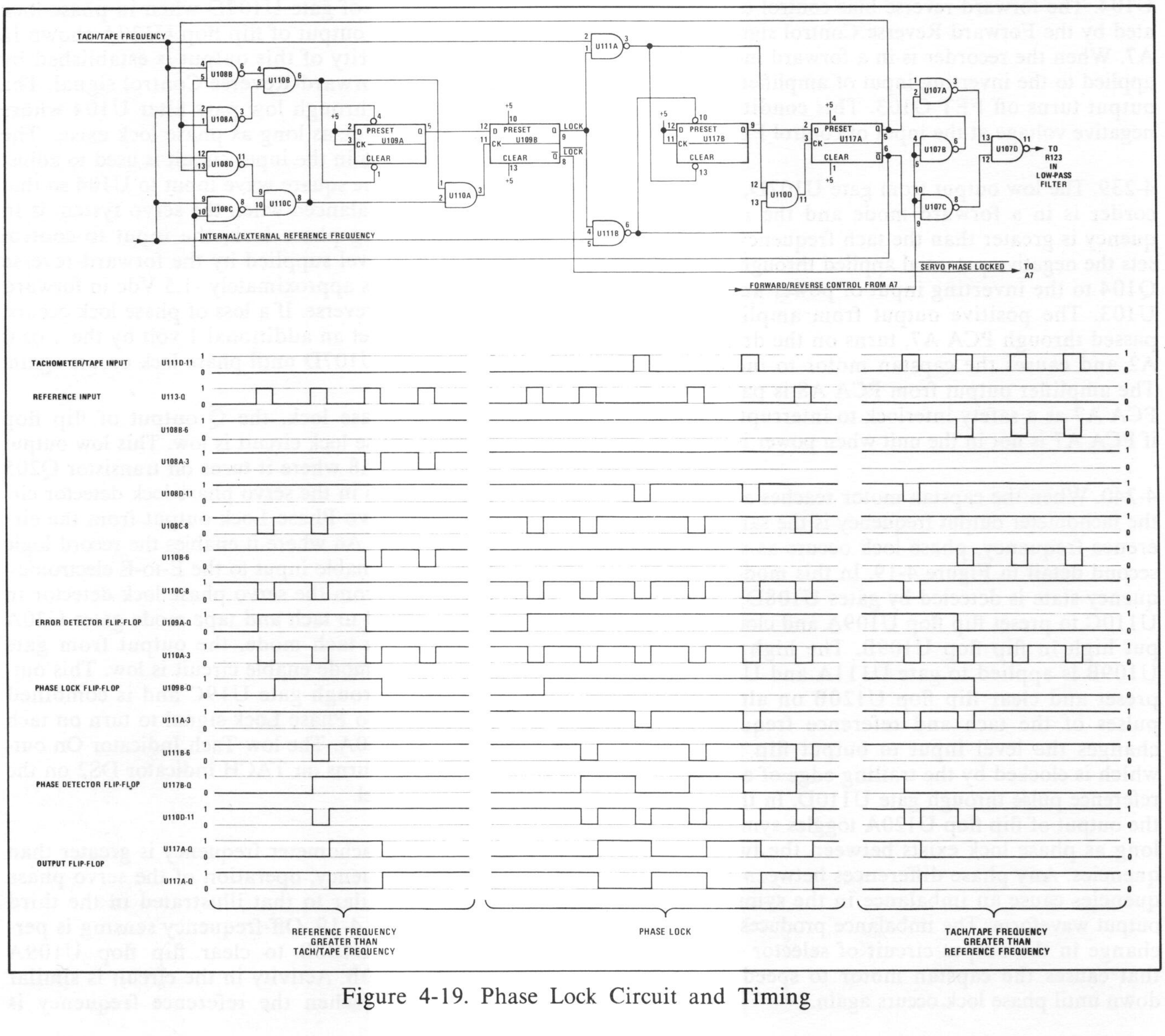


Figure 4-19. Phase Lock Circuit and Timing

Table 4-5. Phase Lock Circuit Outputs

FORWARD/ REVERSE CONTROL	FREQUENCY STATE	LOGIC OUTPUT	VOLTAGE OUTPUT
Forward	Ref > Tach	0	≅ 140 mV
Reverse	Ref > Tach	1	≅ 3.5 V
Forward	Ref < Tach	1	≅ 3.5 V
Reverse	Ref < Tach	0	≅ 140 mV
Forward	Ref = Tach	Toggles	
Reverse	Ref = Tach	Toggles	

U104. The forward-reverse bias control circuit is operated by the Forward-Reverse Control signal from PCA A7. When the recorder is in a forward mode, a high is applied to the inverting input of amplifier U116 whose output turns off FET Q103. This condition applies a negative voltage at the input of control FET Q104.

4-239. The low output from gate U107D, when the recorder is in a forward mode and the reference frequency is greater than the tach frequency, further offsets the negative potential applied through control FET Q104 to the inverting input of power amplifier drive U103. The positive output from amplifier U103 is passed through PCA A7, turns on the drivers in PCA A2 and causes the capstan motor to increase speed. The amplifier output from PCA A8 is passed through PCA A7 as a safety interlock to interrupt motor drive if PCA A7 is not in the unit when power is applied.

4-240. When the capstan motor reaches a speed where the tachometer output frequency is the same as the reference frequency, phase lock occurs as shown in the second detail in Figure 4-19. In this mode, the on-frequency state is detected by gates U108D, U108C and U110C to preset flip flop U109A and clock the Q output high in flip flop U109B. The high output from U109B is applied to gate U111A and U111B, which preset and clear flip flop U120B on alternate input pulses of the tach and reference frequencies. This changes the level input to output flip flop U120A, which is clocked by the trailing edge of each tach and reference pulse through gate U110D. In this condition, the output of flip flop U120A toggles symmetrically as long as phase lock exists between the two input frequencies. Any phase differences between the two frequencies cause an imbalance in the symmetry of the output waveform. The imbalance produces a duty cycle change in the output circuit of selector gate U107D that causes the capstan motor to speed up or slow down until phase lock occurs again.

4-241. The output of gate U107D when in phase lock is the same as the output of flip flop U120A shown in Figure 4-19. Polarity of this output is established by the state of the Forward-Reverse Control signal. The output is passed through low pass filter U104 whose output is near 0 Vdc as long as phase lock exists. The SYM resistor R126 in the input circuit is used to adjust the symmetry of the square wave input to U104 so that the waveform is balanced when the servo system is in phase lock. During phase lock, the input to control FET is the bias level supplied by the forward-reverse bias control, and is approximately -1.5 Vdc in forward and +1.5 Vdc in reverse. If a loss of phase lock occurs, this voltage is offset an additional 1 volt by the 1 or 0 output from gate U107D until phase lock occurs again.

4-242. During phase lock, the $\overline{Q}$ output of flip flop U109B in the phase lock circuit is low. This low output is passed to PCA A8 where it turns off transistor Q205 and turns on Q206 in the servo phase lock detector circuit. The high Servo Phase Lock output from the circuit is sent to PCA A6 where it enables the record logic and removes one enable input to the E-to-E electronics. A second output from the servo phase lock detector in PCA A7 is applied to tach and tape mode gates U20A and U20B. In the tach mode, the output from gate U22A in the tape mode enable circuit is low. This output is inverted through gate U19C and is combined with the high Servo Phase Lock signal to turn on tach mode lock gate U20A. The low Tach Indicator On output from the gate turns on TACH indicator DS2 on the recorder front panel.

4-243. When the tachometer frequency is greater than the reference frequency, operation of the servo phase lock circuit is similar to that illustrated in the third segment of Figure 4-19. Off-frequency sensing is performed by gate U108B to clear flip flop U109A through gate U110B. Activity in the circuit is similar to that occurring when the reference frequency is

greater than the tachometer frequency, except a reversal in the final state of output flip flop U120A is noted. Now in a forward mode, the output of selector gate U107D is a high rather than a low. This condition provides a positive offset to the bias at control FET Q104 that is inverted through drive U103 to slow the motor until phase lock occurs.

4-244. CAPSTAN MOTOR OPERATION.

4-245. Capstan motor drive from low-pass filter U104 is applied to a power amplifier control circuit consisting of FET transistor Q104/Q102 and diodes CR107/CR108 (see Figure 4-20). When the Capstan Motor On signal from PCA A7 is low, diode CR107 is blocked to allow FET Q104 to conduct and couple the drive to power amplifier driver U103. When the Capstan Motor On signal is high, FET transistor Q104 is cut off and the drive path to U103 is interrupted. In this situation, diode CR108 is blocked and FET Q102 is turned on, which lowers the output of U103 to near zero.

4-246. Capstan motor drive is inverted through amplifier U103 and passed through resistor R130 to power amplifiers Q1, Q2, Q5 and Q7 in Motor Drive PCA A2. In a forward mode, input drive to amplifier U103 is a negative level which is inverted and applied to the power amplifiers in PCA A2. Transistors Q5 and Q2 are turned on providing a current path from ground through load resistor R136 on PCA A7 through the power amplifiers to +11 Vdc in PCA A2. In a reverse mode, the output of U103 is negative and turns on power amplifiers Q7 and Q1 in PCA A7, thus connecting -11 Vdc to the motor. A compensating network consisting of A24R7 and A24C10 is located on Interconnect PCA A24 and is connected across the capstan motor. The motor is an inductive device, and the network is installed to make the load appear resistive to the amplifiers thus stabilizing motor operation.

4-247. Motor feedback to the input circuit of amplifier U103 is through a compensating circuit consisting of diodes CR102 through CR105, resistors R132 through R135, capacitors C123 through C127, to FET Q104. Potential at resistor R136 is fed back through the compensating network to the input circuit of amplifier U103, and increases or decreases the capstan motor drive voltage. Small changes in potential are applied across the entire resistive network, which decreases feedback and increases gain. When a large, rapid change in potential occurs, one diode circuit in the network conducts and bypasses resistor R133. This increases feedback and decreases gain of the amplifier circuit.

4-248. A current limiting circuit is installed in the output of amplifier U103 on PCA A8 to limit the maximum motor current to 3.9 amps during acceleration

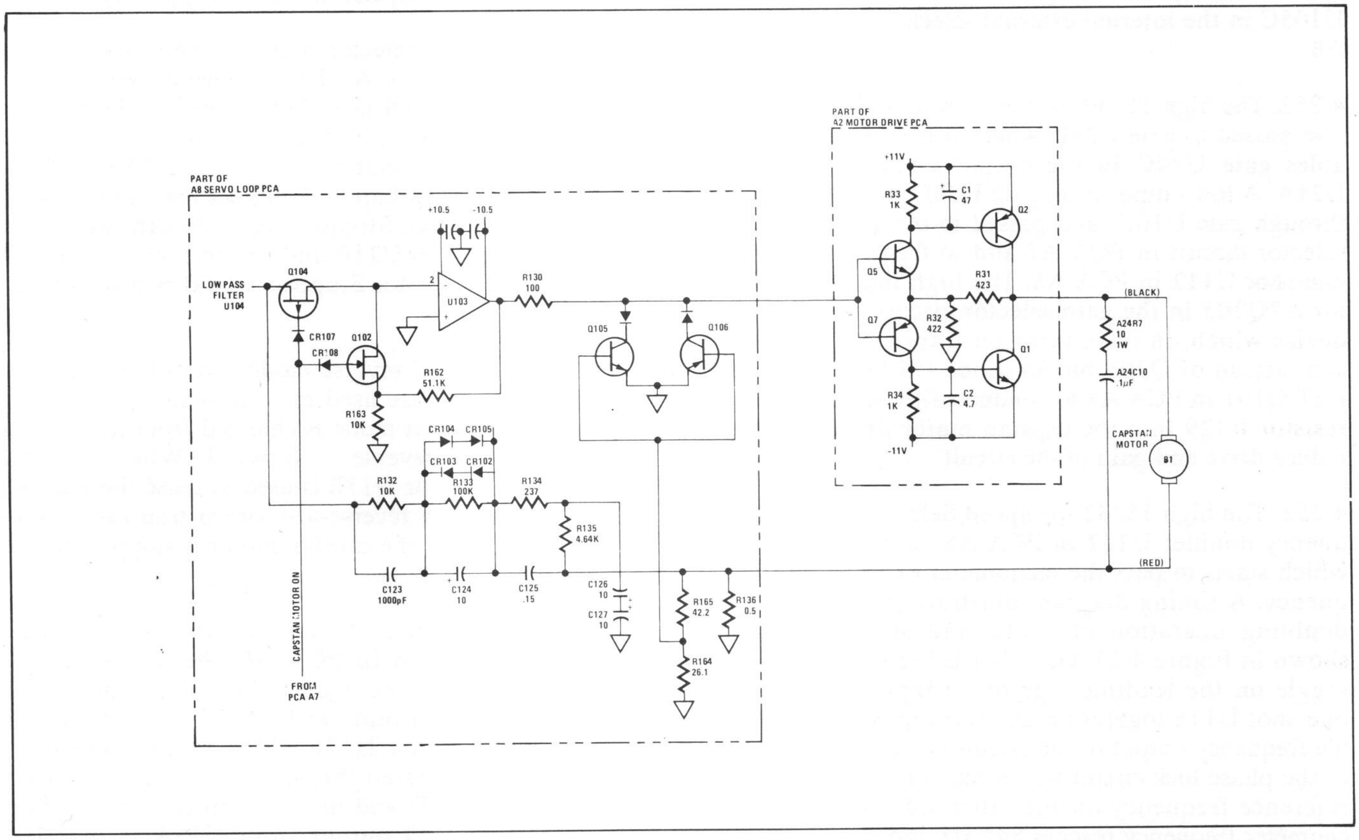


Figure 4-20. Capstan Motor Circuit, Overall Schematic

and deceleration. The circuit uses the potential at resistor R136, and when current through the resistor reaches unsatisfactory levels the potential at the junction of resistors R164 and R165 causes either Q105 or Q106 to turn on. After the current limit is reached and either transistor Q105 or Q106 is on, a further increase in drive level has no effect on motor speed.

4-249. 15/32 IPS SPEED OPERATION.

4-250. To stabilize operation of the servo loop at the lowest tape speed, servo amplifier gain is reduced and phase lock operations are conducted using doubled reference frequencies. As noted in Table 4-3, the internal reference frequency output from divide-by-two flip flop U21A on PCA A7 is 845 Hz during 15/32 ips speed operation. This frequency is passed through the low-pass filter to INTERNAL SERVO REF OUTPUT BNC connector J6 on the rear panel, and to test point TP2 on PCA A8.

4-251. The servo system uses 1.69 kHz reference frequencies rather than the 845 Hz output of flip flop U21A. The internal reference frequency is developed when the 15/32 ips Speed A input to PCA A7 from PCA A6 is active (high). This input sets programmed divider U23 for a divide-by-32 operation (1.69 kHz output), and enables gate U24A in the 15/32 ips Speed Selector circuit. The output from divider U23 is applied through enabled gates U24A and U24B to gate U105C in the internal external selector circuit in PCA A8.

4-252. The high 15/32 ips Speed A input to PCA A7 is also passed to gate U24D where it is inverted and disables gate U24C in the output circuit of flip flop U21A. A low output from gate U24D is inverted again through gate U16D, and passed to the 15/32 ips gain selector circuit in PCA A7 and to frequency doubler one-shot U112 in PCA A8. The high input to transistor A7Q203 in the gain selector circuit turns on that device which, in turn, turns on transistor Q204. The conduction of Q204 blocks diode CR206 and allows FET Q101 in PCA A8 to conduct. This action connects resistor R129 into the capstan motor drive circuit to reduce drive and gain of the circuit.

4-253. The high 15/32 ips Speed Selected input to frequency doubler U112 in PCA A8 enables the device which starts to pass the tachometer or tape input frequency. A timing diagram illustrating the frequency doubling operation of U112 and shaper U116 is shown in Figure 4-21. One-shot U112 is connected to toggle on the leading edge of an input pulse, while one-shot U116 toggles on, the trailing edge. The double frequency output of the circuit is passed to one side of the phase lock circuit which has a 1.69 kHz internal reference frequency on the other side. When the tachometer frequency reaches 845 Hz, indicating that the capstan motor is moving tape at 15/32 ips, the output of the frequency doubling circuit is 1.69 kHz. Frequency and phase lock occurs between the doubled frequency and the 1.69 kHz internal reference and the motor continues to run at the 15/32 ips speed.

4-254. CAPSTAN MOTION DETECTION.

4-255. A capstan motion detection circuit is located on PCA A7 to monitor capstan movement. The circuit consists of dividers U14 and U9 connected to perform a divide-by-100 operation, tachometer frequency one-shot U12B and capstan motion detector flip flop U10A and U10B. When the capstan motor is stopped, there is no tachometer frequency signal present at the input to one-shot U12B. Oscillator output in a standard instrument is 108 kHz which is divided by two in flip flop U6B. The 54 kHz output is by 100 in U14 and U9 which produce an output of 540 Hz.

4-256. As the capstan motor starts to turn, the tachometer frequency from the capstan assembly is applied to pulse shaper U12B in PCA A7 and toggles the one-shot at the tach frequency rate. When motor speed exceeds 540 Hz, one-shot U12B is being clocked at a rate sufficient to keep the $\overline{Q}$ output low. In this state the output of U12B keeps flip flops U10A and U10B cleared. Now the $\overline{Q}$ output of flip flop U10B remains high and has no effect on circuit operation in PCA A7. The clock input to U21B in the capstan direction detector is disabled, and a change in motor direction cannot occur until the capstan motor is stopped again.

4-257. The motion detector is also active when the capstan motor decelerates. As the tachometer frequency input to one-shot U12B falls below 540 Hz, the 540 Hz output of the divide-by-100 circuit overrides the output of U12B and clocks motion detectors U110A/U110B. The $\overline{Q}$ output of flip flop U110B goes low, thus providing the low Capstan Stopped signal to capstan direction detector U16B/U21B and to flip flops U15A and U15B. A low Capstan Stopped signal is also sent to PCA A6.

4-258. Forward and reverse mode detectors U17A and U17B in PCA A7 are used to control servo operation when the instrument mode is changed from forward to reverse or from reverse to forward. When the first event occurs detector U17B is used to sense the change, and U17A senses a reverse-to-forward transition. During each operation, the capstan motor is stopped before changing direction.

4-259. Assuming that a forward-to-reverse mode change has occurred in PCA A6, the Servo control logic is notified by the high-to-low transition of the Forward Command input to PCA A7. This transition is sensed by one-shot U17B which toggles. The one-shot $\overline{Q}$ output is passed through gate U20D, inverted through gate U19D and presets stop control flip flop U15A. The high Q output from U15A is inverted through gate U7B and has no effect on capstan motor

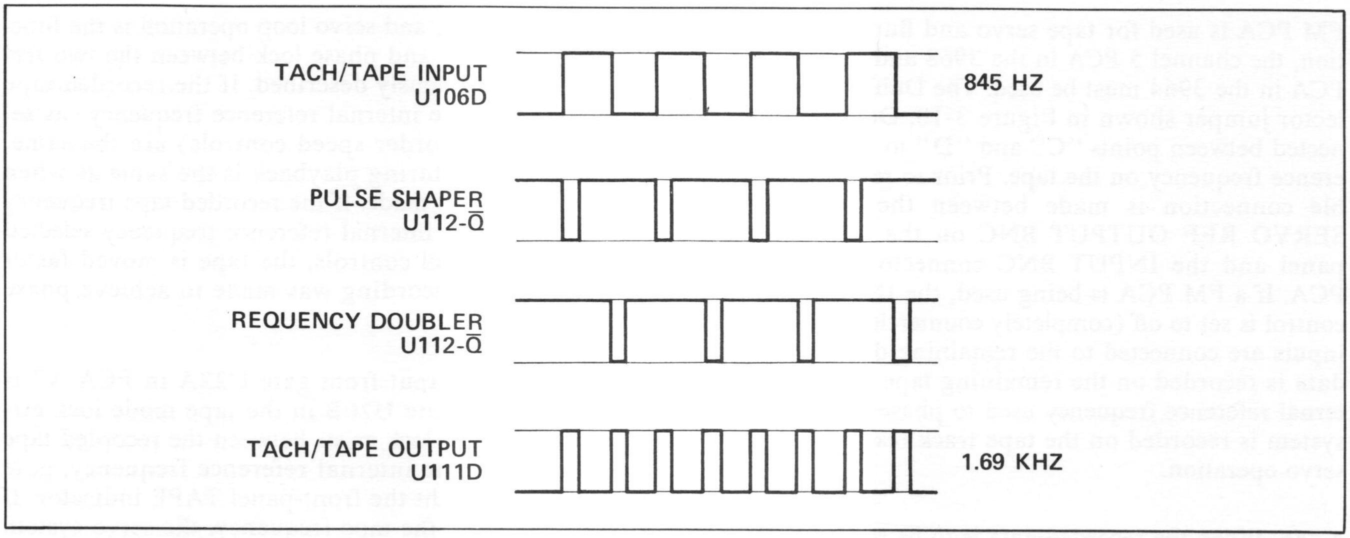


Figure 4-21. 15/32 ips Frequency Doubling, Timing Diagram

on-off control gate U22B which remains enabled during this sequence. A second output from flip flop U15A is inverted through gate U16E and sent to pulse shaper U113 in PCA A8 as a low Reference Frequency Inhibit signal. The low applied to shaper U113 inhibits the device and removes the reference frequency input to the phase lock circuit.

4-260. The servo loop circuits in PCA A8 are still in a forward mode at this time, and by reference to Table 4-5 it can be ascertained that drive to the capstan circuit is a logic 1 when the reference is less than the tachometer. This level is inverted through driver U103 and causes the motor to slow. As the motor slows, the tachometer frequency input slows to the phase detection circuit in PCA A8 and the capstan motion detector circuit in PCA A7. When the Tachometer Frequency input to one-shot U12B falls below 540 Hz the clock output from divider U9 is dominant in the circuit. This causes the $\overline{Q}$ output from flip flop U10B to go low and clock direction detector flip flop U21B. The low Forward Command input to the flip flop is clocked through to provide a low Forward-Reverse Control signal to PCA A8 thereby setting the capstan direction selector gates for a reverse operation. The low output from detector flip flop U10B also clears stop control flip flop U15A, and removes the low Reference Frequency Inhibit signal to pulse shaper one-shot U113. Now the internal reference frequency is applied to the phase detection circuit and the capstna motor starts to move in a reverse direction. If a reverse-to-forward transition occurs, (Forward Command goes high), the change in mode is sensed by forward mode detector U17A in PCA A7. Circuit activity in both PCA A7 and A8 is essentially the same as described for the forward-to-reverse transition.

4-261. CAPSTAN STOP OPERATION.

4-262. The state of the Run Command signal from PCA A6 to PCA A7 controls the on-off state of the capstan motor. When the recorder is operating, the Run Command is high and two conditions can cause the signal to go low: receipt of a stop command or EOT (end-of-tape) signal in PCA A6. The stop command can be generated by use of the front-panel STOP pushbutton, or receipt of a stop signal from a remote control unit. An EOT signal is generated when the unit runs out of tape, or a tape break occurs.

4-263. When the Run Command input to PCA A7 goes low, the signal is inverted through gate U19E in the stop control circuit and clocks flip flop U15A. The high Q output from U15A is inverted through gate U16E to inhibit the Internal Reference Frequency input to the phase lock circuit through one-shot U113 in PCA A8. Simultaneously, the low Run Command input to PCA A7 is inverted through gate U7B and makes one input to gate U22B high. This condition turns on transistors Q209 and Q208 in the drive control circuit and makes the Capstan Motor On signal high to PCA A8. The high signal blocks diode CR108 and allows FET Q102 to conduct. The signal turns off FET transistor Q104 in the same circuit, thus interrupting the drive path to the capstan motor power amplifiers. As the capstan motor slows, the input tachometer frequency decreases, and the capstan motion detector in PCA A7 clears the circuits as previously described.

4-264. TAPE SERVO OPERATION.

4-265. When an accurate playback of recorded data is desired, the same reference frequency that was used during recording can be used to operate the servo system during playback. Tape track 5 (track 2 in the 3964) is normally used for this function, although any channel can be used. A Direct Record Reproduce PCA is recommended for tape servo operation since it requires no modification. An FM PCA can be used to perform this function, as well as flutter compensation, when proper dubbing connections are made. When an

FM PCA is used for tape servo and flutter compensation, the channel 5 PCA in the 3968 and the channel 2 PCA in the 3964 must be used. The Dubbing Input Selector jumper shown in Figure 3-10, Detail C is connected between points "C" and "D" to record the reference frequency on the tape. Prior to recording, a cable connection is made between the INTERNAL SERVO REF OUTPUT BNC on the recorder rear panel and the INPUT BNC connector on the data PCA. If a FM PCA is being used, the INPUT LEVEL control is set to off (completely counterclockwise). Data inputs are connected to the remaining data PCA's. As data is recorded on the remaining tape tracks, the internal reference frequency used to phase lock the servo system is recorded on the tape track reserved for tape servo operation.

4-266. When the recorded data is to be reproduced, the same channel is used to reproduce the reference frequency as was used to record the frequency. A Direct Record/Reproduce PCA used for this function requires no modification, however, the Dubbing Output Selector on a FM PCA must be set. The selector jumper is connected between points "C" and "D1" as shown in Figure 3-10, Detail C. A cable is then connected between the OUTPUT BNC on the PCA and the TAPE SERVO INPUT BNC on the rear panel of the recorder. This connection routes the recorded tape servo reference frequency to input circuits of servo electronics in PCA A7 and A8.

4-267. The recorded tape frequency is applied to tape frequency level detector U13 in PCA A7, and to tape frequency shaper U102 in PCA A8. Detection of the tape frequency provides a low input to tape mode enable gate U22A that is used to sense the recorder state. One controlling input to the gate is the setting of the SERVO TACH-TAPE switch on the recorder front panel. When the switch is set to TAPE, a high Tape Mode Enable signal is applied to transistor Q112 which turns on and applies a low gate U22A in the tape mode enable circuit. If the recorder is being operated remotely, a low Remote Tape Mode Select signal from the remote source overrides the front panel switch setting and provides a low to gate U22A. The two remaining factors in placing the recorder into a tape frequency mode are the modes selected. If a fast forward, fast reverse or record is selected, gate U22A in PCA A7 is disabled by a high Fast Selected or Record Selected Commands. Otherwise, the two inputs are low and gate U22A turns on.

4-268. The high output from gate U22A inverted through gate U19C and applied to tach/tape frequency selector U106 in PCA A8. The low Tape Mode Selected signal is inverted through gate U106B and enables gate U106A. The input recorded tape frequency is passed through gates U106A, U106D and one-shot U116 to one side of the phase lock circuit. The internal reference frequency is applied to the other side of the phase-lock circuit, and servo loop operation is the function of frequency and phase lock between the two frequencies as previously described. If the recorded tape frequency and the internal reference frequency (as selected by the recorder speed controls) are the same, tape movement during playback is the same as when the recording was made. If the recorded tape frequency is lower than the internal reference frequency selected by the front-panel controls, the tape is moved faster than when the recording was made to achieve phase lock.

4-269. A high output from gate U22A in PCA A7 is also applied to gate U20B in the tape mode lock circuit. When phase lock exists between the recorded tape frequency and the internal reference frequency, gate U20B is on to light the front-panel TAPE indicator. If there is a loss of the tape frequency, the servo system automatically switches over to the tachometer frequency. The loss of frequency is sensed at U13 in PCA A7 and causes the output of gate U19A to go high. This inhibits the low Tape Mode Selected signal to PCA A8 and sets tach-tape selector gate U106 so that the tachometer frequency is applied to the phase lock circuit. Concurrently, the output of gate U22A in PCA A7 goes low to inhibit gate U20B and extinguish the front-panel TAPE indicator. The servo loop now phase locks at the speed selected on the front panel and, when phase lock occurs, the output of servo phase lock detector and gate U19C are combined to turn on gate U20A and the front-panel TACH indicator.

4-270. EXTERNAL REFERENCE FREQUENCY OPERATION.

4-271. The recorder servo system can be operated using an external reference frequency instead of the internal reference frequency. To implement this function, a cable connection is made between the external frequency standard and the EXTERNAL SERVO REF INPUT BNC on the recorder rear panel. The internal external servo reference select switch, which is adjacent to the rear-panel BNC connector, is then set to EXT.

4-272. A low input front the internal-external switch is passed to gate U105B in the internal-external selector circuit in PCA A8, and to gate U7A in the external reference stop circuit in PCA A7. The input to gate U105B in PCA A8 is inverted and turns on gate U105A, which passes the external reference frequency to the phase lock circuit. Now, the phase lock circuit operates with the external reference and tachometer frequencies to control capstan operation. To operate the servo system at 15/32 ips with an external reference, the external standard is set to provide an input frequency of 1.69 kHz and 15/32 ips Speed is selected on the front panel. These functions provide the correct parameters for 15/32 ips Servo Operation as described in paragraph 4-249.

4-273. The low External Reference Enable input to PCA A7 is applied to control gate U7A whose output is connected to capstan motor on-off control gate U22B. This input has no effect as long as the external reference frequency applied to pulse shaper U12A is above 540 Hz. The pulse shaper operates with flip flops U11A and U11B in the same manner as the capstan motion detector consisting of U12B, U10A and U10B. The 540 Hz output of the divide-by-100 circuit is applied to the clock inputs of flip flops U11A and U11B, which are held clear by the output one-shot U12A as long as the external reference frequency is above 540 Hz. When the frequency drops below 540 Hz, the divide-by-100 circuit output clocks the $\overline{Q}$ output of flip flop U11B low. This low is combined with the low External Reference Enable signal at gate U7A to provide a high to the input of gate U22B. The low output of U22B causes the Capstan Motor On signal to PCA A8 to change state and shut off FET Q104 in the capstan drive circuit. Removal of drive to the capstan causes the tachometer frequency to drop, which is sensed by the capstan motion detector. When the capstan is stopped, the capstan motion detector circuit clears the various control circuits for a following operation as previously described. However, operation cannot resume until the external reference frequency is restored or the internal-external switch on the rear panel is set to internal. The latter function sets the recorder for internal reference operation.

4-274. FM RECORD-REPRODUCE CIRCUIT DESCRIPTION.

4-275. The FM record and reproduce electronics are located on one PCA, which can be installed in any recorder location, A11 through A18 in the 3968 and locations A11 through A14 in the 3964. These locations can be filled with all FM units, all Direct Record/Reproduce PCA's or a mix of the two. The FM record electronics is used to frequency modulate input data for recording on tape, and the reproduce electronics demodulates and processes the recorded data for delivery to display devices. Both the record and reproduce electronics are illustrated on servicing block diagram Figure 7-34, which also shows ancillary electronics including the bias circuit, calibrator circuit, preamplifier, meter select circuit and the meter amplifier. Schematic diagram references are included with associated descriptions. The following discussion includes descriptions of the record circuit, bias circuit, calibrator circuit, FM unipolar selection, FM dubbing, E-to-E operation, preamplifier, reproduce circuit, FM flutter compensation, meter select circuit and meter amplifier circuit.

4-276. FM RECORD ELECTRONICS.

4-277. The FM record electronics (see Figure 7-40) includes an input buffer amplifier, level shifting amplifier, voltage controlled oscillator, programmable frequency divider, divide-by-two circuit, record head drivers and a bias control circuit. Input data to the record circuit can be through the front-panel INPUT BNC, or through a rear-panel BNC if Option 003 is incorporated. The data is first passed through the contacts of an OPERATE-CALIBRATE switch that is in the position illustrated during operation. Data is then passed to the input buffer amplifier, or to a dubbing input selector if a dubbing operation is being conducted. The latter function is described later in this discussion.

4-278. Resistor R1 in the input circuit of Amplifier U1 is used to set the level of data applied to the tape, and is adjusted by use of the front-panel INPUT LEVEL control. This adjustment is made by an operator prior to recording using the calibrator input. Resistors R2 and capacitor C1 in the input circuit provides high frequency noise rejection, while diodes CR1, CR2, and CR3 protect the input amplifier from high voltage input levels or transients. Amplifier U1 provides a gain of 5 and passes data to the level shifting amplifier.

4-279. Level shifting amplifier U2 provides signal inversion and sets the signal level for proper biasing of the voltage controlled oscillator. The input circuit of the amplifier contains SENS resistor R9, which sets the gain of U2. This control is a circuit board adjustment and is set using a calibration voltage prior to recording. The output of amplifier U2 with a 0V input, is -1.5 Vdc which sets the 54 kHz center frequency of the oscillator. As the input data is applied through U2, the -1.5 Vdc output is shifted and deviates the oscillator frequency. The oscillator operates using a maximum ±40% deviation around the 54 kHz center frequency.

4-280. The frequency modulated carrier output of voltage controlled oscillator Q1 and Q2 is applied through transistor Q4 which provides the proper TTL drive level to programmable frequency divider U3 and divide-by-two flip flop U4B. Operation of the divider circuit is the same as the reference frequency divider used in Servo Control PCA A7 and described in paragraph 4-220. Table 4-3 lists the output frequencies at various speeds, and can be used in this context by substituting U3 for U23 and U4B for U21A in the last two columns. As each speed is selected in PCA A4, the associated Speed A line goes high; i.e., with 15 ips selected, the 15 ips Speed A is high. These inputs establish operation of the programmed dividers and the frequency applied through the dubbing input selector to the record head drivers. The record head drivers are connected push-pull and provide current to drive the record heads. The frequency modulated output from the drivers is passed through a filter network consisting of resistors R30, R31 and capacitor C14 to a bias selector circuit and the contacts of FM record relay K1. The record relay is energized during a record operation by +24V Record Command which is generated by a record relay K4 on Interconnect PCA A24 and passed to all data PCA's. With the FM relay, the FM output from the assembly is passed through Interconnect PCA A24 and a ribbon connector to the associated record

head in the Transport Assembly where the data is recorded on one tape track.

4-281. BIAS OSCILLATOR ELECTRONICS-PCA A4.

4-282. When all eight recording channels are equipped with FM Record/Reproduce PCA's, bias is not required in the FM Assemblies. However, if a Direct Record/Reproduce PCA is included in the recorder, bias should be used to prevent cross talk between record head channels. Bias is developed in Tape Speed Control-Bias Oscillator PCA A4 (see Figure 7-14).

4-283. Operation of the bias oscillator circuit in PCA A4 is controlled by the Record Command input from Interconnect PCA A24. In a record mode, relay A24K4 is energized by a signal from PCA A6 and the Record Command signal is active. In PCA A4, the Record Command signal turns on FET transistor Q1 to enable an oscillator consisting of U1, Q2 and Q3. The oscillator supplies a 300 kHz output that is passed through a filter and voltage amplifier U2 to bias drivers Q4 and Q5. Resistor R14 in the feedback circuit of amplifier U2 is a board adjustment to control the output level.

4-284. The bias supply line and the bias return line from PCA A4 are first passed to a set of jumper connectors on Interconnect PCA A24. If bias is to be used in any of the eight data PCA's, the jumper is connected between pins "B" and "C" as shown in Figure 7-23. If the recorder has all FM data PCA's installed and bias is not required, the jumper on PCA A24 is connected between pins "NB" and "C". This connection grounds the bias line to all data PCA's.

4-285. Each FM PCA has a bias adjustment control on the circuit board. In normal FM operation when the recorder is equipped with a full complement of FM assemblies, track saturation recording is used and bias is not required. In this type operation, the bias jumper in the output circuit of the FM PCA is connected between "C" and "NB", and the bias circuit is inoperative. When the PCA is intermixed with Direct Record/Reproduce PCA's the jumper on the FM PCA is connected between pins "C" and "B". Prior to recording, bias adjustment resistor R28 on the circuit board is adjusted using calibration procedures contained in paragraph 5-73.

4-286. CALIBRATOR ELECTRONICS-PCA A7.

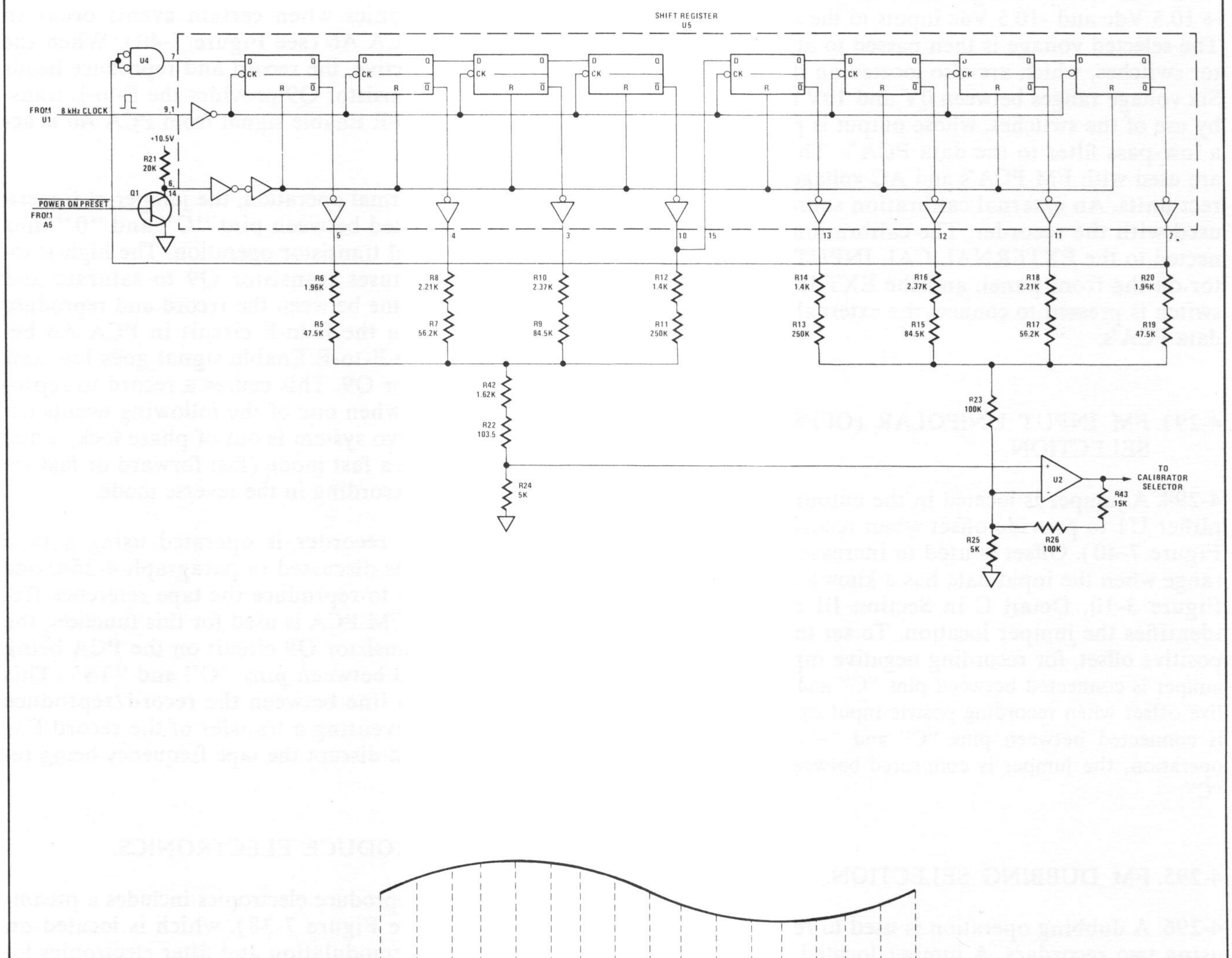
4-287. Calibration electronics, which are used to calibrate FM and Direct PCA's, is located on PCA A7 with the servo control electronics. A separate schematic diagram of the calibrator circuit is contained in Figure 7-27. The calibrator is capable of supplying both AC or DC voltages in six ranges from 0V to 10V. These voltages are used by an operator to set the INPUT LEVEL controls on a data PCA prior to recording, and by maintenance personnel to perform circuit board adjustments.

4-288. The AC calibration voltage is developed by oscillator U1, and a sine wave synthesizer circuit consisting of shift register U5, inverter U4, and resistors R5 through R25. The 8 kHz oscillator consists of voltage controlled oscillator U1 connected in a capacitor – resistor network that established the oscillator frequency. Resistor R3 is a circuit board adjustment that is used to set the output frequency. The 8 kHz square wave output from U1-3 is applied to pins 9 and 1 of shift register U5.

4-289. The shift register (see Figure 4-22) operates with inverter U4, transistor Q1 and amplifier U2 to provide a 500 Hz sine wave output that is used for calibration. When the recorder is turned on, a low Power On Preset signal is applied to the calibrator and turns off reset control transistor Q1. The transistor collector goes high and supplies a reset input to the shift register, and makes all register outputs low. The low output from register pin 2 is inverted through gate U4 and applied to the input circuit of the first element in the register.

4-290. After approximately 250 milliseconds, the Power On Preset signal goes high, transistor Q1 conducts and removes the reset signal from the register. The first clock input after reset is removed sets the first element of the register, which provides a high output at pin 5. This high is applied to the non-inverting input of Amplifier U2 causing the output to go positive. The second clock pulse sets the second element of the register, and causes the output at pin 4 to go high. This reduces resistance in the circuit and causes the output of amplifier U2 to go further positive. The succeeding two clock pulses set elements three and four which provide high outputs at pins 3 and 10. A representation of the output of amplifier U2 is shown in Figure 4-22.

4-291. The high output at pin 10 of the register is fed back through pin 15 to the second section of the register. Each clock input causes successive outputs from pins 13, 12, 11 and 2. The outputs are fed to the inverting input of amplifier U2, whose output reverses and decreases with each succeeding clock input. At the end of eight clock inputs all outputs are equal, therefore, the inputs to both sides of the amplifier are equal and the output is zero. At this time the input to inverter U4 is high and the input to the first element of the register is low. The next clock pulse causes the flip flop to change state and provide a low output from pin 5. Each succeeding clock pulse toggles the following flip flop and makes its output low. The effect on the output of amplifier U2 is shown in Figure 4-22. Since each sine wave output is the product of 16 clock inputs, the resultant frequency output from amplifier U2 is 500 Hz.



REGISTER OUTPUT PIN																	
5	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
4	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
3	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
10	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
13	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
12	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
11	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0
2	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0

0 = GND 1 = 10.5V

SIMULATED U2 OUTPUT

Figure 4-22. Sine Wave Synthesizer Circuit, Functional Diagram

4-292. The amplifier output is applied to a mode selector switch, which is located on the front panel. Three switch sections permit the selection of AC, +DC, or -DC. The latter voltages are derived from regulated +10.5 Vdc and -10.5 Vdc inputs to the switch sections. The selected voltage is then passed to attenuator selector switches, which are also located on the front panel. Six voltage ranges between 0V and 10V can be selected by use of the switches, whose output is passed through a low-pass filter to the data PCA's. The DC voltages are used with FM PCA's and AC voltages with the Direct units. An external calibration source also can be used with the recorder. The calibration input is connected to the EXTERNAL CAL INPUT BNC connector on the front panel, and the EXT INPUT selector switch is pressed to connect the external voltage to the data PCA's.

4-293. FM INPUT UNIPOLAR (OFFSET) SELECTION.

4-294. A jumper is located in the output circuit of amplifier U1 to provide offset when recording data (see Figure 7-40). Offset is used to increase the recording range when the input data has a known single polarity. Figure 3-10, Detail C in Section III of the manual identifies the jumper location. To set the recorder for positive offset, for recording negative input signals, the jumper is connected between pins "C" and "+". For negative offset when recording posivie input signals, the jumper is connected between pins "C" and "–". During normal operation, the jumper is connected between pins "0" and "C".

4-295. FM DUBBING SELECTION.

4-296. A dubbing operation is used to re-record a tape using two recorders. A jumper located in the output circuit of divide-by-two flip flop U4B is used when the recorder is connected for dubbing (see Figure 7-40). Connections required for a FM dubbing operation shown in Figure 4-23. In the first recorder, the Output Dubbing Selector jumper on all PCA's is connected between pins "D2" and "C", and in the second recorder the Input Dubbing Selector is set between "D" and "C". The "D1" pin in the Output Dubbing Selector Circuit is used during a tape servo operation.

4-297. Dubbing can be conducted using all FM PCA's, all Direct PCA's or a mix of FM and Direct. The Direct PCA's require only the OUTPUT to INPUT coaxial connection. Figure 4-23 assumes a full FM complement, therefore, the Bias Selector is shown in a non-bias position. If a mix of FM and Direct are installed the Bias Selector in the FM PCA's are connected between pins "C" and "B" and proper bias control adjustments made for recording. Upon completion of all connections, the first recorder is set to forward and the second recorder to Forward-Record.

4-298. E-TO-E CIRCUIT OPERATION.

4-299. Provisions are included in an FM Record/Reproduce PCA to connect the record electronics to the reproduce electronics when certain events occur in Mode Control PCA A6 (see Figure 7-40). When the E-to-E mode is active, the record and reproduce heads are bypassed. Transistor Q9 provides the E-to-E transfer when the E-to-E Enable signal from PCA A6 is active.

4-300. During normal operation, the jumper at transistor Q9 is connected between pins "C" and "0" thus permitting normal transistor operation. The high E-to-E Enable line causes transistor Q9 to saturate and ground the data line between the record and reproduce electronics. When the E-to-E circuit in PCA A6 becomes active, the E-to-E Enable signal goes low and shuts off transistor Q9. This causes a record to reproduce connection when one of the following events occur: when the servo system is out of phase lock; when the recorder is in a fast mode (fast forward or fast reverse); or when recording in the reverse mode.

4-301. When the recorder is operated using a tape servo reference, as discussed in paragraph 4-264, one data PCA is used to reproduce the tape reference frequency. When a FM PCA is used for this function, the jumper in the transistor Q9 circuit on the PCA being used is connected between pins "C" and "TS". This grounds the data line between the record/reproduce sections, thus preventing a transfer of the record FM signal which could disrupt the tape frequency being reproduced.

4-302. FM REPRODUCE ELECTRONICS.

4-303. The FM reproduce electronics includes a preamplifier circuit (see Figure 7-38), which is located on PCA A10, and demodulation and filter electronics located on the FM Record/Reproduce PCA's (see Figure 7-40). Eight identical two-stage preamplifier circuits (one per data channel) are located on PCA A10. The first stage is a differential amplifier that provides low impedance and low noise, while the second stage provides high gain. The overall circuit operates as a transconductance amplifier, which provides approximately a 100 millivolt output for a microamp input.

4-304. Reproduce data output from the preamplifiers is passed to the associated FM Record/Reproduce PCA whose input circuit contains data equalizer U5 that provides voltage gain, with high input impedance, and upper frequency boost to equalize for recording losses. The input equalization section consists of capacitors C19 through C27 that are switched in parallel with capacitor C26 as the tape speeds change. At 15 ips, capacitor C26 only is in the circuit. At 7-1/2 ips, the input 7-1/2 ips Speed B signal is high (active) to turn on FET transistor Q11. This switch connects capacitor C27 in parallel with C26. Each speed select circuit has

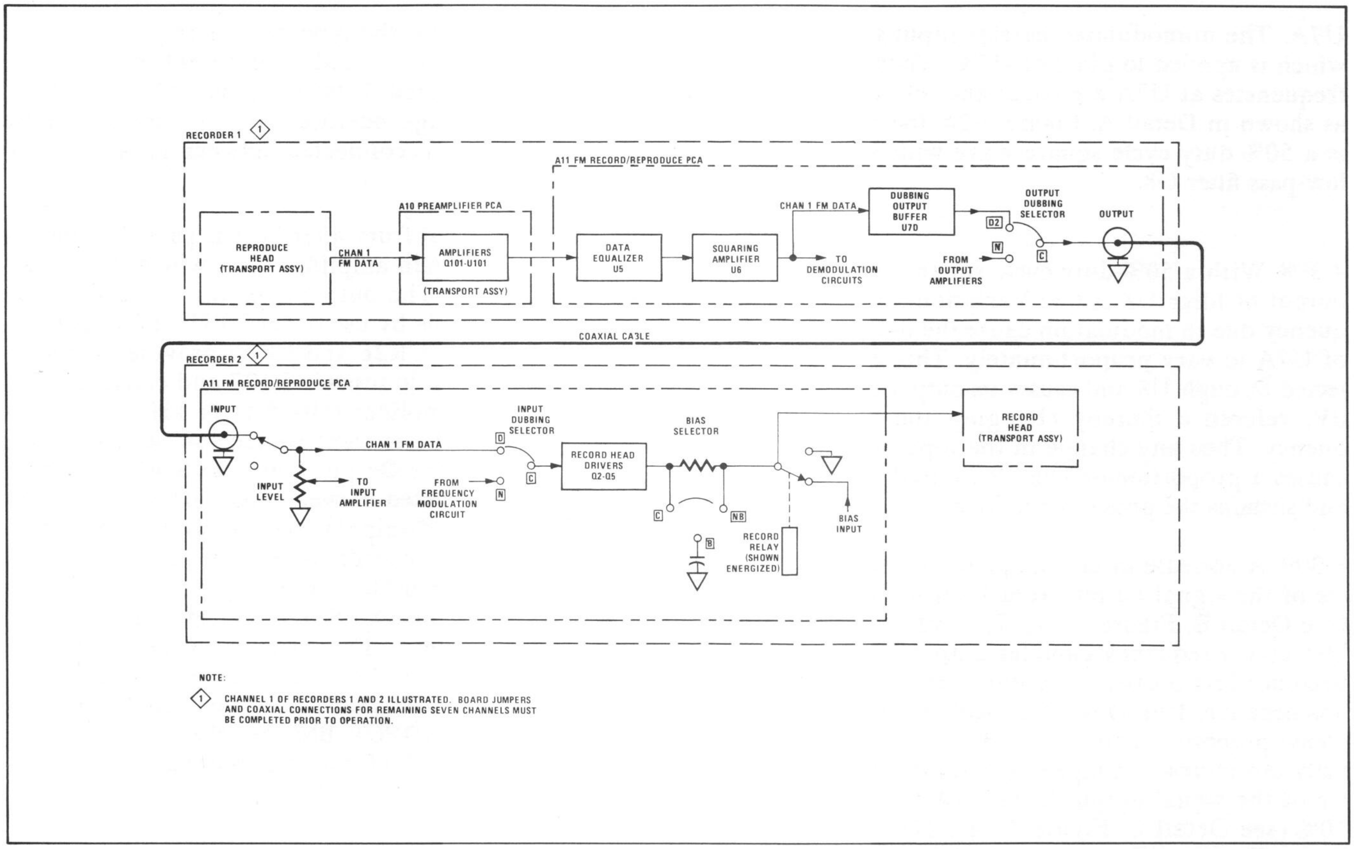


Figure 4-23. Recorders Connected for Dubbing

a diode and FET transistor that is turned on when the speed is selected. When the transistor is on, its associated capacitor is connected into the equalization circuit. In this manner, the band pass is optimum for the tape speed selected.

4-305. The FM data output is passed through a bias filter coil L1 and coupling capacitor C31 to squaring amplifier U6 that is connected to provide signal clipping at a fixed level of approximately 4.5V PK. Equalizer U5 and amplifier U6 act as a filter to provide constant amplitude response over the band pass. An equalization (EQ) selector is connected in the inverting input circuit of amplifier U5. This selector circuit provides minimum signal distortion through equalization. This jumper is set as follows:

A 3964 without bias - Jumper between pins "C" and "1"

A 3964 with bias - Jumper between pins "C" and "2"

A 3968 with or without bias - Jumper between "C" and "2"

A potentiometer connected to pin 1 in the circuit provides equalization control in a 3964 operating without bias. In units operating with bias, equalization is established by use of the bias control. The FM output from amplifier U6 is then applied to phase detector-frequency doubler U7A that is connected with low-pass filter U8A-U8B, voltage-controlled oscillator Q23, Q24 and Q25, programmable divider U9 and divide-by-two flip flop U4A to demodulate the input FM carrier from the tape.

4-306. The voltage-controlled oscillator is connected to operate at a center frequency of 54 kHz. Variable DEMOD resistor R57 located on the circuit board is adjusted to provide 0V out at the center frequency. The output of the oscillator is applied to programmed divider U9 that operates the same as divider U23 on Servo Control PCA A7 (refer to Table 4-3). The output of divider U9 is then passed through divide-by-two flip flop U4A to one side of U7A. The other side of frequency doubler U7A has the input FM signal applied, and the device performs a frequency doubling function, which is part of the phase detection process.

4-307. To examine the phase detection process, assume that a tape speed of 15 ips is selected and that an unmodulated FM carrier is received from the tape. The output from divider U9 at 15 ips is 54 kHz, which is divided by two in flip flop U4A. The 27 kHz output from the flip flop is applied to pin 1 of phase detector

U7A. The unmodulated carrier input is also 27 kHz which is applied to pin 2 of U7A. When the two input frequencies at U7A are equal and 90° apart in phase, as shown in Detail A, Figure 4-24, the output of U7A is a 50% duty cycle square wave which is applied to low-pass filter U8.

4-308. With a 50% duty cycle square wave input, the output of filter U8 is 0V. Variations in the tape frequency due to modulation cause the output duty cycle of U7A to vary proportionately. This variance is detected through U8 and causes its output to vary around 0V, reference thereby changing the oscillator frequency. Thus any change in the input tape frequency causes a proportionate change in oscillator frequency and sustains the phase-locked loop.

4-309. A decrease in tape frequency causes the duty cycle of the signal output from U7A to fall below 50% (see Detail B, Figure 4-24). The average of the Phase Detector/Frequency Doubler output in this situation becomes less positive, therefore, the output of U8 is less negative. This causes the oscillator frequency to decrease proportionately and track the tape frequency exactly. An increase in tape frequency causes the duty cycle of the signal output from U7A to increase above 50% (see Detail C, Figure 4-24). The average of the Phase Detector/Frequency Doubler output becomes more positive, and the output of U8 more negative. This increases the oscillator frequency, which tracks the increase in tape frequency.

4-310. Regardless of the tape speed selected, the two frequency inputs to U7A are the same and phase locked. As an example, at a tape speed of 3-3/4 ips the input tape frequency is 6.25 kHz. With 3-3/4 ips selected, the input 3-3/4 ips Speed A line is high and sets divider U9 to provide a 13.5 kHz output from the 54 kHz input. The 13.5 kHz output is divided to 6.25 kHz, so the two inputs at doubler U7A are equal and phase locked. The data modulating the tape input causes that frequency to change, which produces the variance around 0 Vdc output of U8. This detected data output changes the oscillator frequency to maintain phase lock in the loop, and is passed to low pass filter U10 and U11.

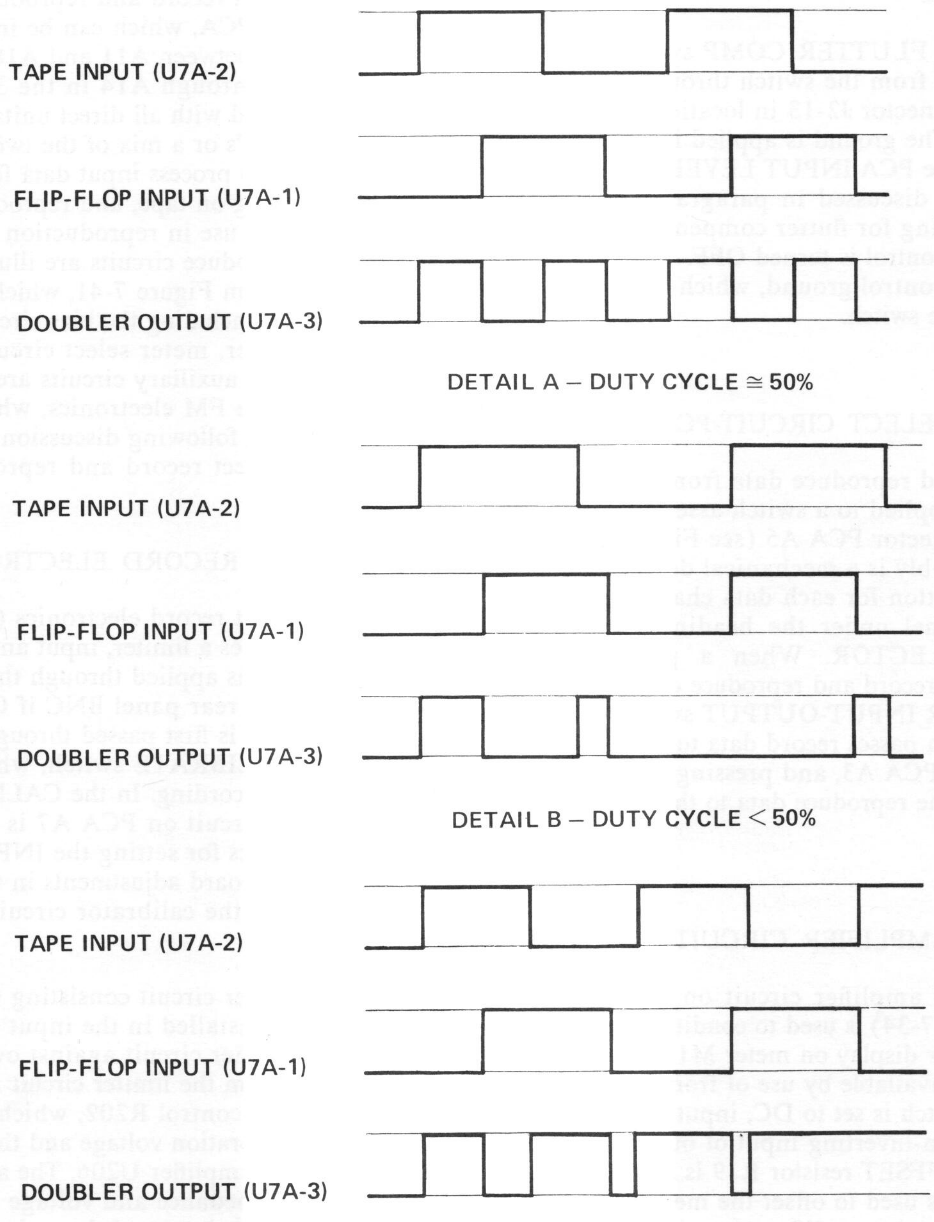
4-311. Filters U10 and U11 are constructed to provide a flat band pass over the FM range, while providing rejection to high frequency transients. Filter U10 is connected in a low Q circuit that provides good response at the lower frequencies, but rolls off at the high end of the band pass. Filter U11 is connected in a high Q circuit that provides peaking at the upper band edge. Each filter contains a selector circuit that adds resistance when a Speed B select line from PCA A4 is high. The high input speed signal blocks its associated diode to turn on the FET transistor and add the resistance in parallel. The input circuit of low pass filter U11 contains an amplitude-phase selector jumper that is used to set the circuit for the type data to be passed. When passing analog data, excluding pulse information, the jumper is connected between pins "C" and "A", which is a stowage position. When handling pulse data, the jumper is connected between pins "C" and "Ø".

4-312. Data output from filter U11 is passed to the inverting input of gain amplifier U12, which drives current driver Q46. The output capability is 2.5V peak, which is adjustable by use of OUTPUT LEVEL resistor R108. Diodes CR26 and CR27 provide over voltage protection, while resistor R107 and capacitor C60 provide output amplifier roll-off at 18 kHz. Transistor Q47 is used as the current source for current driver transistor Q46. The Output Unipolar Selector jumper is normally connected between pins "0" and "C" unless a playback of unipolar data is to be performed. Then the jumper is connected between pins "+" or "–", as applicable, and pin "0". The output circuit also contains an Output Dubbing Selector jumper and a flutter compensation buffer. The dubbing circuit is discussed in paragraph 4-295, and flutter compensation in the following paragraph. Playback data from an FM PCA is taken from the OUTPUT BNC on the front panel, or from a rear panel BNC if Option 003 is installed.

4-313. FM FLUTTER COMPENSATION.

4-314. Flutter is undesired fluctuation in tape speed over the record and reproduce heads. A general discussion of flutter and the compensation for it is contained in paragraph 4-91. Wiring for flutter compensation in the Model 3968 connects the channel 5 FM PCA installed in location A15 with the remaining seven locations (A11 through A14 and A16 through A18). In the 3964, channel 2 is used for flutter compensation and the FM PCA installed in location A12 is the PCA that supplies the buffered output to locations A11, A13 and A14. Any FM PCA's installed in these locations are automatically connected in the flutter compensation circuit (see Figure 7-34).

4-315. Flutter compensation is selected by use of the FLUTTER COMP switch located on the recorder rear panel. When the switch is set OFF, a ground is passed from the switch through connector J1-5 on all PCA's, except the one being used for flutter compensation (A15-3968; A12-3964), to resistor R96 in the input circuit of amplifier U12. Connector J1-5 in location A15 (3968) or location A12 (3964) are permanently connected to ground. When the switch is ON, the non-inverted output of buffer U13 in the PCA in location A15 (3968) or A12 (3964) is passed through connector J1-E and A24J6-11 on Interconnect PCA A24 to the switch, and then back to A24J6-10. From this point, the output is applied to connector J1-5 in locations A11-A18 (3968) or A11-A14 (3964). This non-inverted buffer input is applied to the inverting input



U7A FUNCTIONS

PIN 2	PIN 1	PIN 3
1	1	0
1	0	1
0	1	1
0	0	0

Figure 4-24. FM Phase Detector Timing Diagram

of output amplifier U12. The out-of-phase state between the flutter compensating output and the input to U12 in the remaining FM PCA's produces cancellation of the flutter effect.

4-316. When the FLUTTER COMP switch is ON, a ground is passed from the switch through connectors A24J6-9 and connector J2-13 in location A15 (3968) or A12 (3964). The ground is applied in parallel with a ground from the PCA INPUT LEVEL control to the record relay. As discussed in paragraph 4-93 when making a recording for flutter compensation use, the INPUT LEVEL control is turned OFF. This setting removes the level control ground, which is replaced by the input from the switch.

4-317. METER SELECT CIRCUIT-PCA A5.

4-318. Record and reproduce data from each PCA in the recorder is applied to a switch assembly in Meter Select-Power Detector PCA A5 (see Figure 7-20 and 7-34). The assembly is a mechanical device that contains one pushbutton for each data channel arranged on the front panel under the heading METERED CHANNEL SELECTOR. When a pushbutton is pressed, both the record and reproduce data are passed to the MONITOR INPUT-OUTPUT switch. Pressing the INPUT switch passes record data to the meter amplifier circuit on PCA A3, and pressing the OUTPUT button connects the reproduce data to the meter amplifier.

4-319. METER AMPLIFIER CIRCUIT-PCA A3.

4-320. The meter amplifier circuit on PCA A3 (see Figures 7-11 and 7-34) is used to condition record and reproduce data for display on meter M1. Two methods of operation are available by use of front panel switch S1. When the switch is set to DC, input data is passed directly to the non-inverting input of output amplifier U4A. Variable OFFSET resistor R19 is a circuit board adjustment that is used to offset the meter to a center position by driving the amplifier.

4-321. Setting the switch to the AC position connects the amplification and rectification circuits to the meter. Input data is applied to the non-inverting input of amplifier U1, whose output contains rectification diodes CR4 and CR3. A feedback circuit from the diodes back to the inverting input of the amplifier is used to set and control gain and assures low distortion. Alternate paths are provided for positive and negative outputs. The rectified output is then passed through amplifiers U2 and U3, and a filter and over voltage protection circuit to switch S1. The data is then passed through amplifier U4A to the meter. Variable GAIN resistor R17 is also a circuit board adjustment that is set using an external reference input to the AC Circuit.

4-322. DIRECT RECORD-REPRODUCE CIRCUIT DESCRIPTION.

4-323. The direct record and reproduce electronics are located on one PCA, which can be installed in any recorder location between A11 and A18 in the 3968 and locations A11 through A14 in the 3964. These locations can be filled with all direct units, all FM Record/Reproduce PCA's or a mix of the two. The direct electronics is used to process input data for direct (unmodulated) recording on tape, and reproduce electronics to process data for use in reproduction devices. Both the record and reproduce circuits are illustrated on servicing block diagram Figure 7-41, which also show ancillary electronics including the bias circuit, calibrator circuit, preamplifier, meter select circuit and the meter amplifier. These auxiliary circuits are described in the discussion of the FM electronics, which precedes this description. The following discussion includes descriptions of the direct record and reproduce electronics only.

4-324. DIRECT RECORD ELECTRONICS.

4-325. The direct record electronics (see Figures 7-41 and 7-43) includes a limiter, input amplifier and a bias trap. Input data is applied through the front panel INPUT BNC, or a rear panel BNC if Option 003 is installed. The data is first passed through the front panel OPERATE-CALIBRATE switch, which is set to OPERATE when recording. In the CALIBRATE position, the calibrator circuit on PCA A7 is connected to the record electronics for setting the INPUT LEVEL control and circuit board adjustments in the record circuit. A discussion of the calibrator circuit is contained in paragraph 4-286.

4-326. The limiter circuit consisting of diodes CR201 and CR202 is installed in the input circuit to protect the input amplifier circuit against over voltage input signals. Data from the limiter circuit is passed through INPUT LEVEL control R202, which is set for operation using a calibration voltage and the meter amplifier circuit, to input amplifier U206. The amplifier provides a high input impedance and voltage gain. One output from the amplifier is passed through a meter equalizer circuit, and sent to the meter select circuit on PCA A5 and the meter amplifier circuit on PCA A3 for display on front panel meter M1. The meter equalizer circuit is a passive attenuator that compensates for high frequency boost that occurs in amplifier U206, and provides a flat signal response for the meter application.

4-327. Output data from amplifier U206 is passed through variable resistor R210 and a bias trap to the contacts of record relay K201. Resistor R210 is a circuit board adjustment that is used to set record head current drive. The bias trap is constructed to provide isolation between the amplifier and bias input circuit, and rejects the 300 kHz bias from the oscillator circuit in PCA A4. Development of this AC bias is discussed

in paragraph 4-281. The AC bias input is first passed through a level control circuit, which contains variable resistor R214. This circuit board adjustment is used to provide the proper bias amplitude for data transfer onto the tape. Figure 4-25 illustrates the use of bias in transferring data onto a magnetic tape. Detail A illustrates a transfer with no bias and Detail B a transfer with proper biasing. A detailed discussion of bias considerations is contained in Application Note 89 (HP Part No. 5952-2820), and reference is made to that document for further details.

4-328. Data is transferred from the Direct PCA through the record head to a tape track when the record relay in the PCA is energized. The relay is energized when record relay A24K4 on Interconnect PCA A24 is energized, and the PCA INPUT LEVEL control is away from its off position (full counterclockwise). Relay A24K4 is energized by a Record Command signal from PCA A6 when the recorder is in a play mode

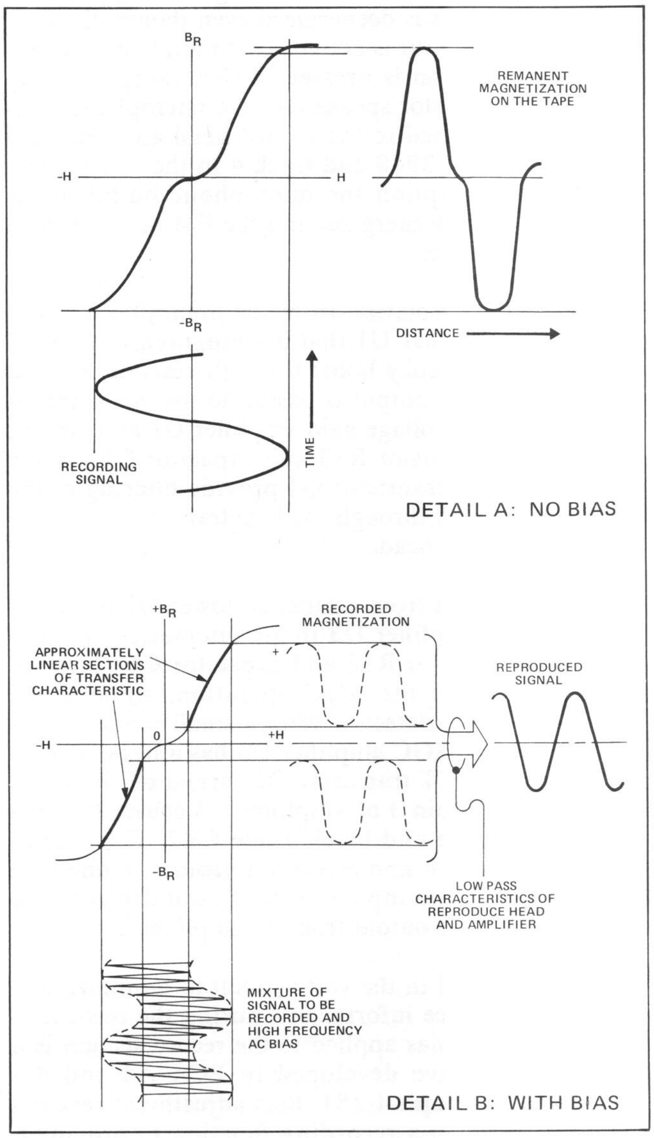


Figure 4-25. Direct Recording Bias Characteristics

(forward or reverse) and the RECORD pushbutton is engaged.

4-329. DIRECT REPRODUCE ELECTRONICS.

4-330. Data retrieved from a tape track is first applied to a preamplifier circuit on PCA A10. This assembly is located in the transport section near the reproduce head to minimize noise pickup. There are eight identical transconductance amplifiers on the PCA (one per tape track), which have very low input impedance. Each amplifier circuit provides a 1 volt output with a 10 microampere input. Data output from the preamplifier is first applied to high-pass filter U201, which provides rejection to frequencies below 50 Hz for Model 3964A or 100 Hz for 3968A. Variable resistor R221 is a circuit board adjustment used to compensate for reproduce head output variations.

4-331. The band edge equalizer stage consisting of amplifier U202 and the band edge equalizer selectors provide boost at the high frequency end of the band pass to extend bandwidth. Each set of equalizer selectors are operated by a Speed B select input signal from PCA A4 that is low when inactive. When a speed is selected, the associated Speed B line goes high and turns on its associated FET switch. The first set of selector switches connects a resistor in parallel with resistor R234 to provide boost at the upper band edge. The second set of switches connect a resistor in parallel with capacitor C227 to provide proper roll-off above the upper band edge. Variable resistor R250, which is a circuit board adjustment, provides high frequency peaking at upper band edge to compensate for reproduce head losses, and diodes CR204, CR205, CR206 and CR207 provide over voltage protection for the equalization circuit.

4-332. Data output from equalizer U202 is passed to a selector circuit consisting of resistors R259, R260, and R258, which are used to select an attenuation value for the high frequency components of input data. The recorder is shipped from the factory with jumper W202 connected between the input circuit of U203 and pin "X" as shown in Figure 7-41. This position is used when high-quality instrumentation tape, which has good high frequency response characteristics, is installed in the recorder and the full boost provided by U202 is not required. Position "Y" reduces the amount of attenuation, and is used when audio tape, with good high-frequency response, is installed in the recorder. Position "Z" provides minimum attenuation and is used when audio tape with average high-frequency response is installed in the recorder.

4-333. A second jumper-select circuit is installed in the input to mid-band equalizer U203. This circuit is an attenuator that is connected between the output of high-pass filter U201 and U203. Attenuation provided by this selector is essentially the same in all positions.

Jumper selection is made using the guidelines as previously stated, with the jumper connected between pin "X" and the input circuit when the instrument is shipped.

4-334. Midband equalizer U203 provides a summing junction for the high frequency data component from U202 and the low frequency component from filter U201. Midband equalizer selectors Q211 through Q215 operate the same as the band edge equalizer selectors, and switch in capacitance to provide proper midband boost at all speeds except 15 ips. The output from U203 is passed through OUTPUT LEVEL resistor R272 and PHASE ADJ resistor R278 to phase Equalizer U204. The output level control is located on the front panel, and is used to set the overall gain of the reproduce section. Resistor R278 is a circuit board adjustment that is used to correct any phase distortion occurring when reproducing pulse data. The phase equalizer circuit compensates for phase distortion that occurs in the band edge circuit by paralleling capacitor C249 with additional capacitance that is added by FET switches Q216 through Q220.

4-335. Data output from equalizer U204 is passed through low pass filter that is used to minimize high frequency noise and any bias transients picked up by the reproduce head. The data is then applied through equalizer U205 that provides low frequency boost, which is controlled by the use of circuit board adjustment R291. This output device also contains two over voltage protection circuits that protect both the input and output of U205 from an over voltage condition that could occur if a voltage source was applied to the output BNC in error. Output data is taken from the front panel OUTPUT BNC, or from a rear panel BNC if Option 003 is incorporated. The reproduce data also is passed to the meter select circuit in PCA A5 and meter amplifier circuit in PCA A3 that are discussed in the description of the FM circuits.

4-336. VOICE RECORD-REPRODUCE CIRCUIT DESCRIPTION.

4-337. The voice record and reproduce electronics are located on PCA A8 with the servo loop electronics described as part of the servo system in paragraph 4-215. The voice circuits are used to make and playback voice recordings, or to annotate FM or direct data being recorded. Both the record and reproduce electronics are illustrated on servicing block diagram Figure 7-28, which also illustrates various circuits that function with the voice circuits. The following description is divided into a discussion of the record electronics and the reproduce circuits.

4-338. VOICE RECORD CIRCUIT.

4-339. The voice record circuit contains a preamplifier, voice amplifier, record head drive and a bias trap (see Figure 7-30). Track 8 on the 3968 tape and track 4 in the 3964 are used for voice operation. The data line from location A18 in the 3968 and location A14 in the 3964, which can house a FM or direct PCA, is routed through the voice circuit on PCA A8 to the record head. This data line is applied to one contact of voice record relay K1 in PCA A8, which has the output of the record circuit on the other contact. Relay K1 is operated by a +24 Vdc Record Command input from record relay A24K4 on Interconnect PCA A24 that is controlled by the record circuit in PCA A6. When the RECORD and forward or reverse pushbuttons on the front panel are operated simultaneously, the low Record Command output from PCA A6 is active and relay A24K4 is energized.

4-340. In PCA A8, voice record relay K1 can only be operated when a microphone is installed in the front panel MICROPHONE jack and its push-to-talk button is pressed. When data from either a FM or direct PCA is being recorded, the data is passed through the voice circuit to the record head. With no ground applied, relay K1 in PCA A8 is deenergized even though the Record Command input is active. To annotate a tape, the microphone button is pressed, which energizes relay K1, and the operator speaks into the microphone. This voice data is passed to the record head and recorded on track 8 in the 3968 and track 4 in the 3964. After the voice interruption the microphone button is released, relay K1 deenergizes and the FM or direct data recording continues.

4-341. Voice information from the microphone is applied to preamplifier U1 that is configured to provide high audio frequency boost through resistor R3 and capacitor C9. The output is passed to the voice amplifier consisting of voltage gain amplifier U2 and emitter following Q1. Resistor R13 and capacitor C11 in the output circuit of transistor Q1 provide filtering of the data that is passed through the bias trap and relay contacts to the record head.

4-342. One output from emitter follower Q1 is passed back through amplifier U3 in an automatic gain control circuit. Resistor R18 and capacitor C15 provide signal integration for AGC operation, while diode CR1 is the circuit detector. With a small signal output at transistor Q1, AGC amplifier U3 has a negative output that keeps FET transistor Q2 turned off. A signal exceeding 1V at pin 3 of amplifier U3 causes the output to go positive and block diode CR7. This allows FET Q2 to turn on and connect a ground to one side of resistor R5 in the input circuit of head driver U2 to attenuate the voice output from preamplifier U1.

4-343. Bias is used in the voice circuit to minimize distortion of the voice information during the recording process. The AC bias applied to the record section is a 300 kHz sine wave developed in PCA A4 and described in paragraph 4-281. Bias adjustment resistor R17 is set prior to a recording function to provide a correct biasing level to the record head. An illustration

of the effect of using bias during a recording is shown in Figure 4-25. The bias trap consisting of Coil L1 and Capacitor C13 is used to isolate the bias supply and the voice record circuit.

4-344. VOICE REPRODUCE CIRCUIT.

4-345. The voice reproduce circuit, which is also located on PCA A8, consists of an equalizing amplifier, a gain amplifier, power driver and a speaker (see Figures 7-28, and 7-30). Track 8 data in the 3968 and track 4 data in the 3964 is detected and amplified in preamplifier A10 and passed to Interconnect PCA A24 where a circuit split occurs. One data line goes to the channel 8 (3968)/channel 4 (3964) FM or direct PCA and the second to the voice reproduce circuit in PCA A8. Regardless of the type data on the line, both circuits receive the information.

4-346. Input voice data to the reproduce section is applied to equalizing amplifier U4. At tape speeds of 7-1/2 and 15 ips the state provides unity gain. At the lower four tape speeds, capacitance is switched into the circuit by FETS Q3 through Q6 to provide high frequency audio boost. At these four low speeds, the active Speed B line from PCA A4 is high to block the associated diode and allow the FET to turn on.

4-347. Output data from U4 is passed to gain and low frequency equalizer U5. A gain of approximately 60 is derived from the relationship of resistors R30/R31 to R28, and low frequency boost is provided by capacitors C23 and C24 that supply a negative feedback to roll off higher frequencies. Voice data from amplifier U5 is passed across VOLUME resistor R32 to drive amplifier U6 and current drivers Q8 and Q7. Resistor R36 in the negative input circuit of U6 is used to bias the DC output level of drivers Q7 and Q8 to approximately +4 Vdc. Resistors R34 and R35 are feedback elements that set the gain of U6. Voice output from drivers Q7 and Q8 are applied to the HEADPHONE jack and speaker on the front panel. With headphone installed, the data path to the speaker is interrupted. If the recorder is in a record mode, relay A24K4 is energized and removes speaker ground to disable the device while recording.

4-348. POWER SOURCES CIRCUIT DESCRIPTION.

4-349. There are nine power sources in the Model 3968 and Model 3964 Recorders that are identified in paragraph 4-107. The following discussion includes a description of each power source and introduces applicable servicing block and schematic diagrams.

4-350. POWER INPUT AND +24 VDC SUPPLY.

4-351. The recorder power input circuit and regulated +24 Vdc supply are illustrated in servicing block diagram Figure 7-13. Source AC is applied to the recorder through rear panel connector J1. This AC source can be 100, 120, 220, or 240 Vac, +5% -10%, 48-66 Hz, and is passed through AC CIRCUIT BREAKER CB1, also located on the rear panel, to POWER ON-OFF switch W9S1 located on the front panel. From the POWER switch the AC input is applied to an AC VOLTAGE SELECTOR switch on the rear panel.

4-352. To set the recorder for operation with 100 Vac, +5% -10% both the left and right hand slide switches are set to the positions shown in Figure 7-3. For 120 Vac operation, the left hand slide is set to the 240-120 position and the right hand slide remains in the position shown. For 220 Vac operation, the left hand slide is set to the 100-220 position and the right hand slide to the 240-220 position. For 240 Vac operation, the left hand slide is set to the 240-120 position and the right slide to the 240-220 position. Each slide setting from 100 Vac to 240 Vac reconfigures the windings in the primary of power transformer T1.

4-353. The secondary of transformer T1 contains rectifiers for the ±16 Vdc and ±11 Vdc supplies, and the +24 Vdc supply under discussion. The first two supplies are discussed later in this description. Bridge rectifier IC CR1 and a filter network consisting of resistor R1 and capacitor C1 are located on Interconnect PCA A24. The unregulated +24 Vdc output is regulated by IC U2 that is located on the recorder chassis. The regulated +24 Vdc is used to operate reel motor control relays K1, K2 and K3, and record relay K4 all located on Interconnect PCA A24. One contact of the record relay also has the +24 Vdc applied and, when relay K4 is energized, supplies the Record Command to relay K1 in the VOICE circuit of PCA A8, and to record relays in each of the FM or Direct PCA's installed in locations A11 through A18 (3968) or A11 through A14 (3964).

4-354. The A24 Record Command signal also is passed to the bias oscillator circuit in PCA A4. Application of the command enables FET Q1 and turns on the oscillator. A regulated +24 Vdc is passed to remote control connector J2 on the rear panel for use with a user supplied remote control unit. This supply would normally be used as a lamp current source, as is the case in PCA's A4 and A6 where the +24 Vdc is used in the lamp circuits.

4-355. 16 VDC SUPPLIES.

4-356. A second winding in the secondary of power transformer T1 is connected to bridge rectifier IC CR2 that is located on the chassis. The rectifier provides an unregulated +16 Vdc and -16 Vdc input (see Figure

7-19) to Interconnect PCA A24 that is filtered in a network consisting of capacitors C2, C3, C4 and resistors R2 and R3. One +16 Vdc supply is used to develop a regulated +10.5 Vdc that is discussed later in paragraph 4-358. The unregulated +16 Vdc is also used in PCA A4, PCA A7 and by transistor Q1 on Interconnect PCA A24. The +16 Vdc is used to develop a regulated voltage for use with a voltage amplifier and the bias drivers in the bias oscillator section of PCA A4. In PCA A7 the +16 Vdc is regulated and used as a supply for the AC amplifier and output state in the calibrator section. Transistor Q1 is a current driver for the reel motor brake solenoid.

4-357. The unregulated -16 Vdc supply is also passed to PCA's A1 and A3 for use to develop a regulated -10.5 Vdc that is discussed in paragraph 4-358. The unregulated -16 Vdc is also used in PCA A4 and PCA A7. In PCA A4, the supply is used to develop a regulated voltage for use in the bias oscillator electronics. In PCA A7 the voltage is regulated for use in the calibrator circuit.

4-358. 10.5 VDC SUPPLIES.

4-359. Regulated +10.5 Vdc and -10.5 Vdc supplies are developed from the unregulated +16 Vdc and -16 Vdc supplies discussed in the preceding paragraph. The two regulators are located on Meter Amplifier/10.5V Regulator PCA A4 with their associated pass transistors contained on 5V(B) Regulator PCA A1. Both circuits are shown in servicing block diagram Figure 7-9, and schematic diagram Figure 7-11.

4-360. The +10.5 Vdc and -10.5 Vdc regulators in PCA A3 are essentially the same, therefore, this description is confined to +10.5 Vdc regulator only. The unregulated +16 Vdc supply is applied to PCA A3 through pass transistor Q3 in PCA A1, and directly through pin 14 to a reference circuit consisting of resistor R102 and diode CR102. The voltage developed across diode CR102 is used during initial turn on to provide a reference to error amplifier U102. When the output voltage reaches normal, a precision reference circuit consisting of resistor R113 and CR107 in the output circuit provides the reference voltage to amplifier U102. This voltage is slightly higher than that developed by CR102 to back bias CR106, thus disconnecting the turn-on reference circuit.

4-361. Current limiting in the regulator is performed by resistor R105 that is connected in series with the source and load, and amplifier U101. Any large increase in load current causes the input to the inverting side of amplifier U101 to go positive. This produces a more negative potential at the inverting input to error amplifier U102, and causes regulator Q101 to decrease conduction thereby decreasing conduction of pass transistor Q3.

4-362. Voltage regulation is provided by a voltage sensing network consisting of resistors R111, R114 and variable resistor R112, which is a circuit board adjustment. The resistor is provided to adjust the +10.5 Vdc output from the module. Changes in output voltage are sensed across the network and applied to the non-inverting input of error amplifier U102. If a drop in voltage occurs, a low potential is applied to the non-inverting input of error amplifier. This causes the output of U102 to go negative to increase the conduction of regulator Q101 and pass transistor Q3 to raise the output voltage.

4-363. The regulated +10.5 Vdc is used to reference error amplifier U104 in the -10.5 Vdc regulator circuit, which operates in the same manner as the +10.5 Vdc regulator. Current limiting is provided by resistor R118 and amplifier U103, and output voltage sensing is provided by resistors R125 and R124. The circuit that includes diode CR115 and resistor R131 is used to develop an operating voltage for current limiter U101 in the +10.5V regulator rather than a reference voltage. The regulated +10.5 Vdc and -10.5 Vdc are used for operating voltage in PCA's A4, A5, A6, A7, A8, A9, A10, and A11 through A18 as shown in Figure 7-9.

4-364. 11 VDC SUPPLIES.

4-365. A third winding in the secondary of power transformer T1 is connected to bridge rectifier IC CR1 which is mounted on the chassis. The rectifier provides an unregulated +11 Vdc and -11 Vdc output (see Figure 7-4) that is filtered by a network consisting of capacitors C5 through C9, and resistors R4 and R5 on Interconnect PCA A24. One unregulated +11 Vdc supply is used to operate the reel motors, and is applied through the contacts of stop-run relay K1 on PCA A24. Routing of this +11 Vdc supply is shown in Figures 7-17 and 7-18. A second +11 Vdc supply is sent to the HP-IB installation if Option 007 is installed in the recorder. Distribution of this voltage is shown in Figure 7-44. The +11 Vdc is also used to develop the regulated +5 Vdc(A) supply and +5 Vdc(B) supply discussed in the following paragraph.

4-366. +5 VDC SUPPLIES.

4-367. There are two regulated +5 Vdc supplies in the recorder, one located on PCA A1 and the second on PCA A2. The +5 Vdc(A) supply is illustrated in Figures 7-4 and 7-6, and the +5 Vdc(B) supply is shown in Figure 7-4 and 7-8. Both supplies contain a pass transistor, current limiter error amplifier, regulator and over voltage protection. The regulators are conventional and operate in the same manner as the 10.5V regulator circuits described in paragraph 4-358. The over voltage protection in the output circuit of each regulator is a crowbar type using SCR diodes CR2 and

CR8. The regulated +5 Vdc(A) supply provides operating voltage to the FM and Direct PCA's. The regulated +5 Vdc(B) supply is used in PCA's A3, A4, A5, A6, A7, A8 and A9 as shown in Figure 7-4.

4-368. OVERLAP CIRCUIT DESCRIPTION (OPTION 070).

4-369. The Recorders are equipped for overlap operation when long-term recording capability is desired. This function is accomplished by connecting two or more recorders in tandem so that one recorder starts when the preceding recorder stops. Two recorders connected in tandem are shown in Figure 7-31 and the overlap electronics are shown in Figure 7-33.

4-370. The overlap electronics are located on Overlap PCA A9, which operates with Mode Control PCA A6 and a light emitting diode, photo transistor and STOP-OFF-REWIND switch located on the transport assembly. In a recorder with the overlap option installed, setting the recorder to forward provides a low Overlap Enable signal that is passed to Overlap PCA A9. The low input is inverted through gate U6C and is used to enable output gates U6A and U6B, and gate U5A in the variable delay circuit.

4-371. Overlap operation starts in free running multivibrator U1 that provides a 500 Hz, 20 μsec pulse output. One output is sent to one-shot U4, and a second output is passed through transistors Q3, Q2 and Q1 to the light emitting diode in the transport assembly. Transistor Q3 provides phase inversion and gain, transistor Q2 is a current amplifier and transistor Q1 is a decoupler. As the diode is pulsed, it emits light pulses toward the photo detector. With a full supply reel of tape, minimum light is detected and the input to preamplifier U2 is small and has no effect. When approximately 1/8 inch of tape remains on the reel, the detected output is large enough to initiate overlap operation.

4-372. Preamplifier U2 detects photo current proportional to light intensity, and provides a pulse output for each surge of photo current. GAIN resistor R9 is used to set circuit gain and is preadjusted for approximately a 3 Vpp output with an empty supply reel on the recorder. This preadjustment sets the circuit to provide approximately a 1.5 Vpp pulse output when the tape pack on the reel is down to 1/8 inch. The input circuit of threshold detector U3B is constructed to detect levels exceeding 1.5V, and provides a positive-going pulse output to one-shot U4.

4-373. Pulse stretching one-shot U4 requires coincidence between the multivibrator input and the threshold detector input to toggle. When the pulse input from U1 is negative going and the input from U3B is positive going and in coincidence, the one-shot Q output goes high and the $\overline{Q}$ output low. This coincident window is but 20 μsec thereby blocking extraneous noise pulses. The pulse output from buffer U3C is a positive going pulse that is stretched to approximately 1000 μsec by the RC network in the one-shot circuit. The positive going pulse is passed through another threshold detector U3D that inverts the pulse and minimizes the possibility of transients toggling the output circuit.

4-374. The negative output of U3C is inverted through gate U5B and combined with the high Overlap Enable signal at output gate U6A and U6B to provide a low Overlap Forward Command and Overlap Record Command output from PCA A9. The two low commands are routed to remote control connector J2 on Interconnect PCA A24, and then to the Mode Control PCA in the second recorder as shown in Figure 7-15. Receipt of the two input commands automatically set the second recorder in the forward-record mode.

4-375. The high pulse output from gate U5B is combined with the overlap Enable signal at gate U5A and toggles one-shot U7. Variable TIME resistor R19 in the one-shot circuit can be adjusted to provide an output that is delayed from 20 to 120 seconds. This delay is incorporated so that the user can delay stopping the recorder until the following recorder is in full operation. This arrangement assures continuity of information recorded by the two recorders. After U7 times out, the output is shaped in one-shot U8B and passed through inverter U6D to the STOP-REWIND switch in the Transport Assembly. If the switch is in the STOP position, the low Stop-Rewind Enable signal is passed to the run-stop logic in Mode Control PCA A6 and stops the recorder immediately. If the switch is set to REWIND, the low Enable signal is passed to forward-reverse logic and slow-fast logic in PCA A6. This sets the recorder to the fast-reverse mode, which is continued until the right reel is emptied and the recorder is stopped by an EOT (end of tape) condition. If the switch is set to OFF, the recorder continues to run forward until the left reel is emptied, and EOT stops the recorder.

4-376. HP-IB INTERFACE CIRCUIT DESCRIPTION (OPTION 007).

4-377. The HP-IB electronics is used to permit operation of the recorder by a controller using the standard instrumentation interface techniques defined in IEEE Standard 488-1975. The HP-IB circuits are contained on four printed circuit assemblies (PCA's) that are identified, with their functions, as follows:

a. A19 Interface PCA: Interfaces the HP-IB electronics with the recorder electronics; provides interface between the Interconnect, Listen Control, and Talk Control PCA's; contains address and control character decoders.

b. A20 Listen Control PCA: Contains the electronics to provide listen handshake interchanges with the

controller; provides enabling levels to the control character decoder; provides control levels to the Talk Control PCA during a talk function.

c. A21 Talk Control PCA: Monitors the recorder end-of-tape (EOT) circuit; notifies the controller if an EOT condition exists; contains the electronics to permit the recorder to participate in error identification polls; provides error indications to the controller if an EOT condition exists.

d. A22 Interconnect PCA: Interfaces the recorder to the controller; contains level converters to change control and data levels from negative true to positive true; contains address selector switch (accessible on the rear panel) to permit changing the recorder's binary address.

4-378. During a recorder listen operation, the controller uses two control/handshake lines (ATN = attention and DAV = data valid) and seven data lines (D10 1 through D107) to pass addresses and control characters to the recorder. There are actually eight DIO lines available at the recorder connector, however, only seven are used between controller and recorder. The recorder, in turn, uses two handshake lines (RFD = ready for data and DAC = data accepted) to complete the transfer cycle.

4-379. During a recorder talk operation, both the controller and recorder act as talkers and listeners. First the controller acts as a talker, and uses the ATN and DAV lines with the seven DIO lines to pass serial poll and address characters to the recorder. The recorder uses the DAV control line and the seven DIO lines to transfer a recorder identification character. The controller uses the RFD and DAC lines to complete the character transfer from recorder to controller.

4-380. All control and data interchange from controller to recorder during a listen operation is made with negative true levels (1=true=0V; 0=false=2.5V). These levels are converted to positive true (1=true=2.5V; 0=false=0V) immediately after receipt in the HP-IB electronics. The control interchange from recorder to controller during a listen function is positive true.

4-381. Control and data interchange from controller to recorder during a talk operation when the controller is the talker is negative true. This also is converted to positive true immediately after application to the HP-IB electronics. Control and data interchange from recorder to controller when the recorder is the talker is negative true. The following circuit descriptions use servicing block diagram Figure 7-44 for reference. A more detailed circuit analysis can be made using schematic diagram Figure 7-46. A general discussion of a typical HP-IB installation is presented in paragraph 4-116. Reference is made to that over view as an introduction to the following detailed description.

4-382. LISTEN FUNCTIONS.

4-383. The listen electronics in the recorder is used to transfer mode and speed commands from the controller to the recorder. Figure 4-26 is a state diagram of the recorder electronics as the unit moves through address and control word transfers. This state diagram is a modified version of the acceptor handshake (AH) diagram shown in the IEEE Standard 488-1975. The ANRS state (acceptor not ready state) is not used in the recorders, and is not illustrated in Figure 4-26. This state is normally used to permit an acceptor to perform internal operations before moving to the ACRS state (acceptor ready state). To move from the ANRS to ACRS state, an acceptor uses an internally generated RDY (ready) signal. In recorder operations, time required to perform internal operations is included in handshake timing, therefore the RDY signal is not used and ANRS is not illustrated.

4-384. When power is first applied to the recorder, a Power On Preset signal generated in the recorder performs the PON (power on) function to place the recorder in the AIDS state (acceptor idle state) as illustrated in Detail A, Figure 4-26. The recorder makes both RFD (ready for data) and DAC (data accepted) true to indicate that it is in AIDS. When the controller has data to pass to the recorder, the recorder must be addressed. First the controller moves the recorder to the ACRS (acceptor ready state) by making ATN (attention) true. The recorder responds when it is in ACRS by making RFD true and DAC false. The controller then places the listen address on the DIO lines and makes DAV (data valid) true indicating that valid data is on the DIO bus. This function moves the recorder to the ACDS (accept data state), and the recorder responds by making RFD and DAC false. The recorder goes through a 4 μsecs short handshake delay and automatically enters the AWNS state (acceptor wait for new cycle state). At this time the recorder is in a LADS state (listener addressed state), and has RFD false and DAC true. The controller moves the recorder back to the ACRS state by making DAV false, where a control character can be transferred again on the data lines.

4-385. To transfer data rather than an address, the controller makes ATN false (see Detail B, Figure 4-26). When ATN goes false, the recorder Listener Address State (LADS) is converted to a LACS (Listener Active State). In the recorder, this state replaces ATN to move the recorder through the ACDS and AWNS states back to ACRS. With the recorder in ACRS and with LACS active, the controller makes DAV true and places the control character on the DIO lines. The recorder now enters the ACDS state and makes RFD and DAC false. The recorder goes through a 60 millisecond long handshake and automatically enters the AWNS state with RFD false and DAC true. The controller now makes DAV false and returns the recorder

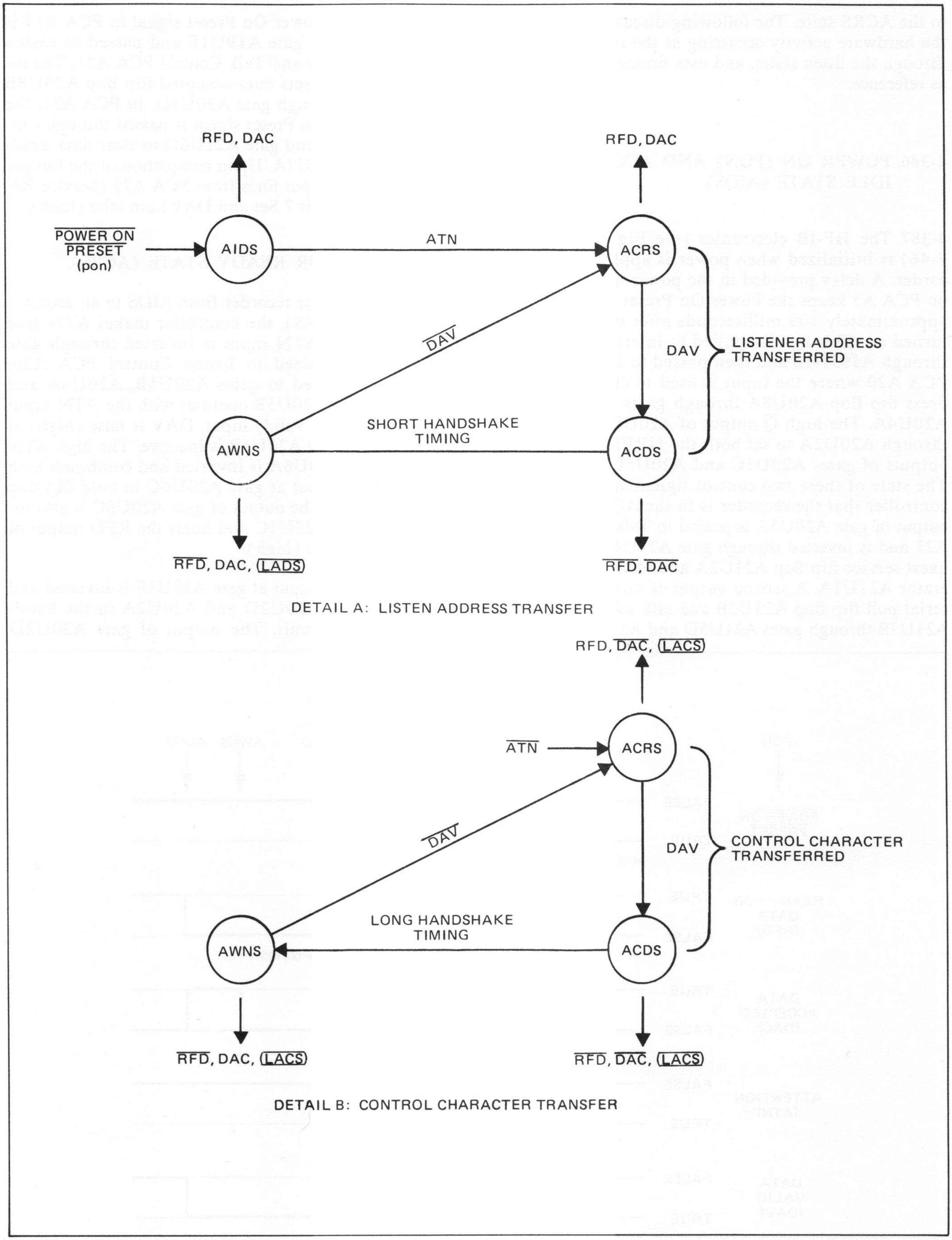


Figure 4-26. Recorder Acceptor Handshake State Diagram

to the ACRS state. The following discussion describes the hardware activity occurring as the recorder moves through the listen states, and uses timing diagram 4-27 as reference.

4-386. POWER ON (PON) AND ACCEPTOR IDLE STATE (AIDS).

4-387. The HP-IB electronics (see Figure 7-44 and 7-46) is initialized when power is applied to the recorder. A delay provided in the power detector circuit on PCA A5 keeps the Power On Preset signal low for approximately 100 milliseconds after the recorder is turned on. This low is applied to Interface PCA A19 through A19J1-12 and then passed to Listen Control PCA A20 where the input is used to clear listen address flip flop A20U8A through gates A20U5A and A20U4A. The high $\overline{Q}$ output of A20U8A is inverted through A20U2A to set both the NRFD and NDAC outputs of gates A20U5C and A20U5D true (high). The state of these two control signals indicate to the controller that the recorder is in the AIDS state. One output of gate A20U5A is passed to Talk Control PCA A21 and is inverted through gate A21U4D to clear request service flip flop A21U2A and identification generator A21U1A. A second output of this source clears serial poll flip flop A21U2B and talk address flip flop A21U7B through gates A21U5D and A21U6B.

4-388. The low Power On Preset signal in PCA A19 is inverted through gate A19U1E and passed to Listen Control PCA A20 and Talk Control PCA A21. The inverted signal presets data accepted flip flop A20U8B on PCA A20 through gate A20U6D. In PCA A21, the inverted Power On Preset signal is passed through connector A21P1-D and gate A21U6D to clear data available flip flop A21U7A. Upon completion of the foregoing events, all output lines from PCA A21 (Service Request, Bit 6 Set, Bit 7 Set and DAV) are false (high).

4-389. ACCEPTOR READY STATE (ACRS).

4-390. To move the recorder from AIDS to an acceptor ready state (ACRS), the controller makes ATN true (low). The low ATN input is inverted through gate A22U1F and passed to Listen Control PCA A20, where it is applied to gates A20U5B, A20U6A and A20U1F. Gate A20U5B operates with the ATN input and a DAV (data valid) input. DAV is false (high) at this time and gate A20U5B is inactive. The high ATN input at gate A20U6A is inverted and combined with the low DAV input at gate A20U6C to hold flip flop A20U8B preset. The output of gate A20U6C is also inverted through A20U1C and holds the RFD output of gate A20U5D true (high).

4-391. The ATN input at gate A20U1F is inverted and passed to gates A20U2D and A20U2A in the handshake control circuit. The output of gate A20U2D

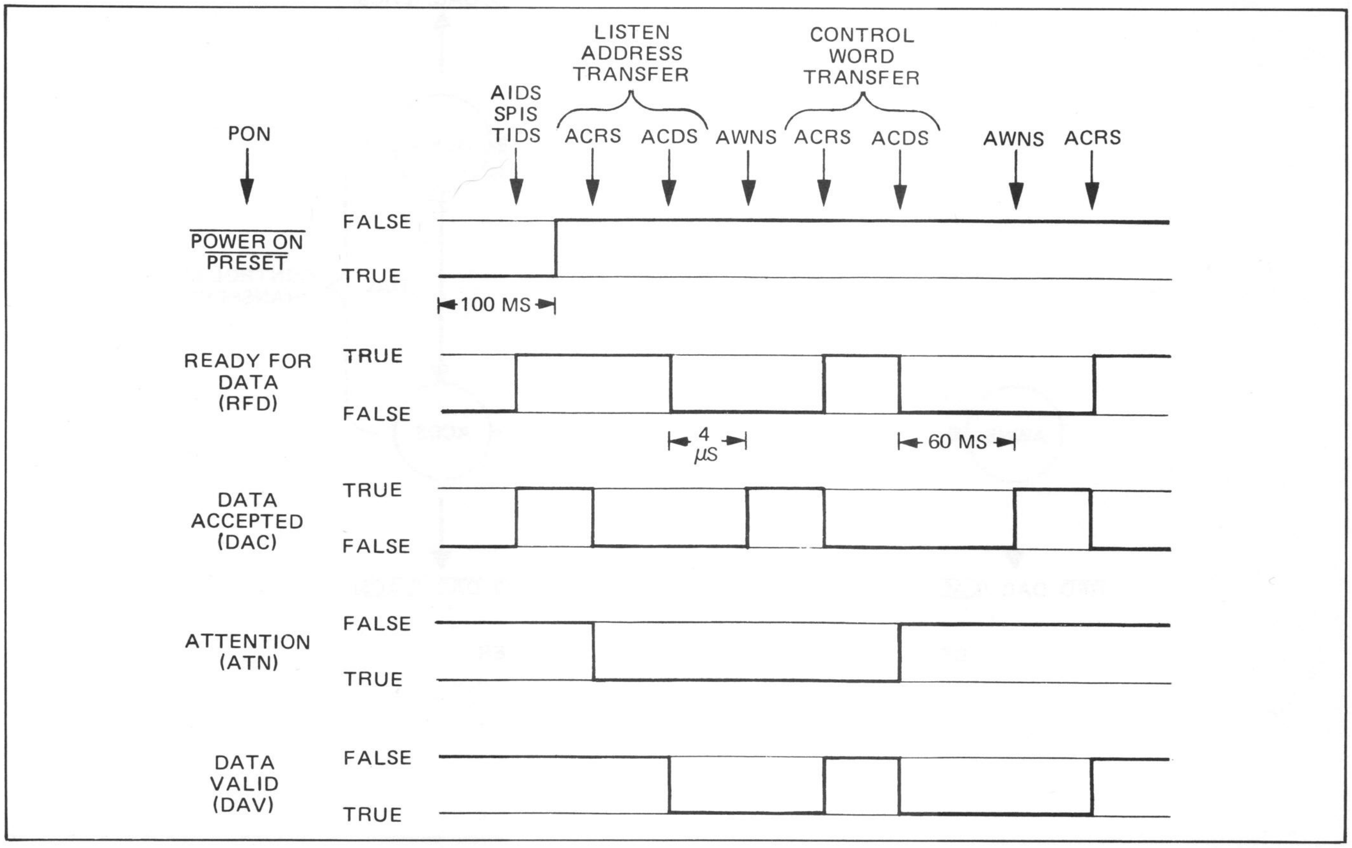


Figure 4-27. HP-IB Listen Function Timing Diagram

causes a low-to-high transition in the output of gate A20U2B that toggles long handshake one-shot A20U7B. At the end of delays the output of A20U7B goes low and clocks data accepted flip flop A20U8B; however, the device is immediately preset by the output of gate A20U6C and this transition has no effect on circuit operation.

4-392. The inverted ATN output of gate A20U1F also is passed through gate A20U2A and places a high on one side of DAC and RFD output gates A20U5C and A20U5D. The DAC output of gate A20U5C goes low (false) when the output of gate A20U2A is combined with the inverted output of data accepted flip flop A20U8B, which is preset ($\overline{Q}$ low). The RFD output at gate A20U5D remains high due to the output of the DAC/RFD control gate A20U6C that is inverted through gate A20U1C. With the DAC output low (false) and the RFD output high, (true) the recorder is in the ACRS state.

4-393. ACCEPT DATA STATE (ACDS).

4-394. The recorder is moved from the ACRS state to the ACDS state using the DAV line. During this operation, the ATN signal is used to identify the DIO input data as an address or control word. When ATN is low, the DIO data is an address. Setting the ATN line high identifies the DIO data as a control word.

4-395. The low ATN input from the controller provides the same circuit activity as described in the preceding paragraphs, except the low state at gate A20U2D maintains a high output at gate A20U2B in the handshake control circuit rather than causing a low-to-high transition. This condition inhibits operation of long handshake one-shot A20U2B during an address transfer. The transfer is initiated when the controller makes DAV true (low). This low input is inverted through A22U1B and applied to gate A20U5B in the listen address enable circuit, to gate A20U6C in the DAC/RFD control circuit, and to gate A20U2C in the handshake control circuit. With ATN and DAV true gate U5B is on, and its output is combined with the output of a listen address decode circuit to preset listen address flip flop A20U8A. This function places the recorder in the listener Addressed State (LADS). Transfer and decoding the listener address is discussed in paragraph 4-397.

4-396. The high DAV input at gate A20U6C removes the preset signal to data accepted flip flop A20U8B, however, the $\overline{Q}$ output remains low to hold the DAC output of gate A20U5C low (false). The high DAV input at gate A20U6C also provides a high input at gate A20U5D and causes the RFD output to go low. With both the DAC and RFD outputs false, the recorder is in the ACDS state.

4-397. The high DAV input at gate A20U2C is combined with the output of gate A20U2A and toggles short handshake one-shot A20U3A. The output of A20U3A goes high and after 4 microseconds makes a high-to-low transition. This transition clocks DAC flip flop A20U8B causing the DAC output of gate A20U5C to go high. With the DAC output true and RFD false, the recorder moves to the AWNS state.

4-398. LISTEN ADDRESS TRANSFER.

4-399. As DAV goes low during the ACDS cycle, the controller places the listen address on the DIO lines. The listen address for the recorder is the ASCII character "1" that has the bit pattern shown in Table 4-6.

4-400. The first five bits of a listen or talk address are decoded by gate A22U2, while the determination of whether the address is listen or talk is established by the levels of bits 6 and 7. DIO lines 1 through 5 are passed through inverted buffers A22U3A, A22U3B, A22U3C, A22U3D and A22UE to address selector switch S1, which is on the recorder rear panel. The same five outputs are also passed through inverters A19U8A, A19U8B, A19U8D, A19U8E and A19U8F on PCA A19, then returned back to PCA A22 and a second set of contacts in switch S1.

4-401. To set the recorder for use with the ASCII "1" address, switch section S1-A and S1-E are set to ON. Bits 1 and 5 or the recorder address from the source are true (low). The bits are inverted through buffers A22U3A, A22U1E and applied directly through switch sections S1-A and S1-E, which are on, to address decode gate A22U2. Bits 2, 3, and 4 of the address are false (high). These bits are inverted through A22U3B, A22U3C, A22U3D and through A19U8E, A19U8D, A19U8A, then applied to address switch S1. Switch sections S1-B, S1-C, and S1-D are set to OFF, and apply the high outputs of inverters A19U8E, A19U8D, A19U8A to gate A22U2, which now has all inputs high and is enabled.

4-402. The output of gate A22U2 is inverted through gate A19U1F and applied to listen address decoder A19U4B and talk address decoder A19U4C. The listen address has the bit structure shown in Table 4-6, with bit 6 true (low) and bit 7 false (high). A talk address has bit 6 false and bit 7 true. When setting the listen address, bit 6 of the address is low, which is inverted through A22U1A and applied to listen address decoder A19U4B. Input bit 7 of the address is high, which is inverted through A22U3E and also applied to gate A19U4B. Thus, a correct 7-bit listen address for the recorder enables A19U4B and, with ATN and DAV low, presets listen address flip flop A20U8A. The preset state of A20U8A places the listen electronics in the listener Addressed State (LADS) as discussed in paragraph 4-384.

Table 4-6. Listen DIO Bit Patterns (Source Input)

CONTROL	ASCII CHARACTER	DIO 8	DIO 7	DIO 6	DIO 5	DIO 4	DIO 3	DIO 2	DIO 1
Listen	1	X	0	1	1	0	0	0	1
Unlisten	?	X	0	1	1	1	1	1	1
1 = TRUE (0V)		0 = FALSE (2.5V)				X = IRREVELANT			

4-403. CONTROL WORD TRANSFER.

4-404. To transfer a control word after a listen address has been transferred, the recorder is moved from the AWNS state to ACRS. The controller makes DAV false (high), which is inverted and applied to gate A20U6C in the DAC/RFD control circuit. Gate A20U6D also has an inverted output from delay one-shot A20U7A applied and turns on when the DAV input goes false. The output of gate A20U6C presets data accepted flip flop A20U8B to provide a high to one side of gate A20U5C. The $\overline{Q}$ output of preset listen address flip flop A20U8A is inverted and applied to the other side of A20U5C causing the DAC output to go false (low). Concurrently, a second high output from gate A20U6C in the DAC/RFD control circuit is inverted through A20U1C and causes the RFD output of gate A20U5D to go true (high). The recorder is now in the ACRS state with DAC false and RFD true.

4-405. To transfer a control character, the controller first releases ATN which goes false (high) and then makes DAV true (low). The inverted input at gate A20U6C causes a low output that removes the preset signal to DAC flip flop A20U8B, and places a high on one side of RFD output gate A20U5D. The inverted $\overline{Q}$ output of preset listen address flip flop A20U8A is applied to the other side of gates A20U5C and A20U5D. Flip-flop A20U8B is still in a preset state at this time and provides a low output that sets the DAC output false (low). The two highs at gate A20U5D also set the RFD output false and, with both DAC and RFD false, the recorder is in the ACDS state.

4-406. The inverted DAV input also is combined with the inverted $\overline{Q}$ output of preset flip flop A20U8A to turn on gate A20U2C in the handshake control circuit. The output of gate A20U2C toggles both short and long handshake flip flop A20U3A and A20U7B. One-shot A20U3A has no effect on circuit operation during a control character transfer since its time constant is shorter than the time constant of A20U7B. The output of toggled one-shot A20U7B goes high and remains high for 60 milliseconds. At the end of delay, the high-to-low transition clocks DAC flip flop A20U8B causing its output to reverse and make DAC true (high). With DAC true and RFD false the recorder moves to the AWNS state.

4-407. When listen address flip flop A20U8A is preset, the high Q output is passed to decoder enable gate A19U7B on PCA A19. This device enables control word decoder and requires four inputs to turn on the decoder. In addition to the output of flip flop A20U8A, the device receives another input when ATN goes false (refer to paragraph 4-405), and a third input when one-shot A20U7B is toggled (refer to paragraph 4-406). The last input requirement is satisfied when the control word is decoded which is discussed in the following paragraph.

4-408. Simultaneously with the assertion of the high ATN and low DAV signals, the controller places a control character on the DIO lines. The ASCII equivalents for the 8 recorder mode control characters are listed in Table 4-2, and the 6 recorder speed control words in Table 4-7.

4-409. Three bits of a control word on the DIO lines are passed to control word decoder A19U7A, and the remaining 4 bits to control word decoder A19U5. An examination of the source input bit patterns of all the control words listed in Table 4-7 and 4-8 indicate the same structure for bits 7, 6 and 5 (1,0,0). DIO bit 7 (True = 0V) is passed through one inverter and is applied to A19U7A as a high. DIO bits 6 and 5 (False = 2.5V) are passed through two inverters and applied to A19U7A as highs. DIO line 8 is not connected to the controller and is always false (2.5V on PCA A22). With all inputs high, A19U7A is on and

Table 4-7. Mode Control Bit Patterns (Source Input)

MODE	ASCII CHARACTER	DIO BIT PATTERN 8	7	6	5	4	3	2	1
Forward	G	X	1	0	0	0	1	1	1
Reverse	L	X	1	0	0	1	1	0	0
Forward Record	F	X	1	0	0	0	1	1	0
Reverse Record	M	X	1	0	0	1	1	0	1
Fast Forward	I	X	1	0	0	1	0	0	1
Fast Reverse	J	X	1	0	0	1	0	1	0
2 Second Delay	O	X	1	0	0	1	1	1	1
Stop	K	X	1	0	0	1	0	1	1
1 = TRUE (0V)		0 = FALSE (2.5V)			X = IRRELEVANT				

passes the enabling signal to decoder enable gate A19U7B which, in turn, enables control word decoder A19U5.

4-410. The structure of the 4 bits of a control word applied to decoder A19U5 cause a low output on one of the 14 lines in the output section. The functional operation of decoder A19U5 is listed in Table 4-9.

4-411. A decoded control word is passed from PCA A19 to Interconnect PCA A24 in the recorder and then distributed to the appropriate module. Speed Commands are routed to Tape Speed Control/Bias Oscillator PCA A4. Mode Commands are sent to Mode Control PCA A6. In each module the HP-IB circuits parallel front panel controls and input lines from a remote control unit. When the recorder is being operated through HP-IB electronics, care should be exercised that the remote control lines and front panel controls, which are still active, are not used. Functions of the input speed commands are shown in Figure 7-7 and mode control functions are shown in Figures 7-3 and 7-5.

4-412. While a control word is transferred from the controller to the recorder, decoded and passed to the speed or mode electronics, as applicable, long handshake one-shot A20U7B continues its delay cycle. At the end of 60 milliseconds, the Q output of A20U7B goes low, enables gate A20U6D in the DAC flip flop clock circuit, and clocks data accepted flip flop A20U8B. The high $\overline{Q}$ output of the flip flop, causes the DAC output of gate A20U5C to go high indicating that the recorder has accepted the data and moves the recorder to the AWNS state. The 60 millisecond time interval between transferring and accepting the data permits the recorder to react to a command before accepting a following command. The controller then

Table 4-8. Speed Control Bit Patterns (Source Input)

SPEED	ASCII CHARACTER	DIO BIT PATTERN 8	7	6	5	4	3	2	1
15 ips	E	X	1	0	0	0	1	0	1
7-1/2 ips	B	X	1	0	0	0	0	1	0
3-3/4 ips	D	X	1	0	0	0	1	0	0
1-7/8 ips	C	X	1	0	0	0	0	1	1
15/16 ips	H	X	1	0	0	1	0	0	0
15/32 ips	A	X	1	0	0	0	0	0	1
1 = TRUE (0V)		0 = FALSE (2.5V)			X = IRRELEVANT				

Table 4-9. Control Word Decoder Operation

ENABLE PINS		INPUT DIO BITS				OUTPUT PINS														OUTPUT COMMAND
		PIN NOS.																		
18	19	20 4	21 3	22 2	23 1	2	3	4	5	6	7	8	9	10	11	13	14	15	17	
0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	15/32 ips Speed
0	0	0	0	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	7-1/2 ips Speed
0	0	0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1-7/8 ips Speed
0	0	0	1	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	3-3/4 ips Speed
0	0	0	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	15 ips Speed
0	0	0	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Forward & Record
0	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	Forward
0	0	1	0	0	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	15/16 ips Speed
0	0	1	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	Fast Forward
0	0	1	0	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	Fast Reverse
0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	Stop
0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	Reverse
0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	Reverse & Record
0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	2 Second Delay
1 = TRUE (+2.5V)											0 = FALSE (0V)									

moves the recorder back to the ACRS state using the false DAV signal, making the unit ready for a further data transfer.

4-413. LISTEN DELAY FUNCTION.

4-414. A two-second listen delay circuit is included in PCA A20 to allow a controller to inject delay in recorder response to commands when desired. Such a delay could be used when placing the recorder in operation to permit the device to go to reach the desired mode and speed. This two second delay is implemented by holding the RFD output low for two seconds after receipt of the two second delay control word.

4-415. The two second delay control word is the ASCII character 0, which is constructed with bits 1 through 4 true. Control word decoder A19U5 makes output pin 17 low upon receipt of the two second delay character, as shown in Table 4-9. This low toggles two second delay one-shot A20U7A, and causes the $\overline{Q}$ output to go low. This low causes the output of gate A20U6C in the DAC/RFD Control Circuit to go low, which holds off the preset of data accepted flip flop A20U8B. The inverted output of gate A20U6C also keeps gate A20U5D enabled and maintains the low RFD output to the controller. When one-shot A20U7A ends its delay, the $\overline{Q}$ output goes high and normal recorder controller operations can continue.

4-416. UNLISTEN (UNL) CONTROL.

4-417. The recorder listen HP-IB electronics can be placed in the idle state when the controller has completed operations, or when exercising the talk electronics. To place the recorder listen electronics into idle, the controller uses the command as shown in Table 4-6. DIO bits 1 through 6 are true (0V) at the controller, and are inverted on PCA A22 before application to "unlisten" decoder A19U6. DIO bit 7, which is false

(0V) at the controller, is inverted twice before application to A19U6. The output of the decoder is passed through "unlisten" control gate A19U2D to gate A20U4D in the listen address disable circuit. To transfer the UNL command, the controller makes ATN then DAV true. This turns on gate A20U5B whose output is combined with the output of gates A19U2D and A20U1B to turn on gate A20U4D. This input clears listen address flip flop A20U8A, and places the listen electronics in the idle state.

4-418. When the controller is using the recorder talk electronics, talk address decoder A19U4C is active. The low output from the gate is passed through "unlisten" control gate A19U2D and also clears listen address flip flop A20U8A. This function also places the listen electronics in an idle state.

4-419. TALKER FUNCTIONS.

4-420. The talk electronics is initialized at the same time as the listen electronics by the Power On Preset signal discussed in paragraphs 4-387 and 4-388. The power on (PON) condition sets the listen electronics to a SPIS state (serial poll idle state) and a TIDS state (talker idle state) as shown in Figure 4-28. When an EOT (end-of-tape) condition exists in the recorder, a Service Request (SRQ) signal is generated in the HP-IB talk electronics and sent to the controller. Since the controller is operating with a number of devices, a serial poll is conducted by the controller to determine which unit has made the service request.

4-421. The serial poll is initiated by the controller moving the listen electronics from AIDS to ACDS using the true ATN and DAV signals as shown in Detail A, Figure 4-26 and described in paragraphs 4-383 and 4-384. The recorder responds by changing the RFD and DAC levels as indicated. When moving from the ACRS state to ACDS state, the controller places an SPE (serial poll enable) address on the DIO lines to activate the talk electronics serial poll logic. Now with IFC (interface clear) false, the recorder in the ACDS state and SPE on the DIO lines, the recorder moves from the SPIS to SPMS (serial poll mode state) as shown in Detail A, Figure 4-28.

4-422. The foregoing events enable the serial poll circuits in all units on the interface bus. Now, the controller interrogates each unit individually by setting the talk address logic. When the recorder is interrogated, the controller again moves the listen electronics to the ACDS state using true ATN and DAV levels. When moving from the ACRS state to the ACDS state the controller places the talk address on the DIO lines to actuate the talk logic. With IFC false, the recorder in the ACDS state and the talk address (MTA) on the DIO lines, the recorder moves to the TADS state (talk addressed state) as shown in Detail B, Figure 4-28.

4-423. With the talk electronics in the TADS state, two paths can be taken. If the logic is in the SPMS state (see Detail A, Figure 4-28) and the controller makes ATN false, the recorder moves from the TADS state to the SPAS state (serial poll active state). In this state, the recorder becomes a talker and the controller a listener to pass the recorder identification characters to the controller. If the logic is not in the SPMS state and the controller makes ATN false, the recorder moves to the TACS state (talker active state). In TACS, the recorder sends a null character (all DIO lines false) to the controller. The following discussion describes the hardware activity occurring as the recorder electronics moves through the various talk states using timing diagram Figure 4-29 as reference.

4-424. SERVICE REQUEST (SRQ).

4-425. The circuits in Talk Control PCA A21 (see Figure 7-44) are also initialized by the Power On Preset signal discussed in paragraph 4-386, and all flip flops are in the clear condition. A talk function is initiated by the recorder when an EOT (end-of-tape) condition occurs. When the recorder tape runs out or breaks, a low Delayed End of Tape signal is developed in Mode Control PCA A6. This input signal is inverted through gate U3D in Talk Control PCA A21 and applied to gate A21U9A in the service request enable circuit. Both serial poll flip flop A21U2B and request service flip flop A21U2A are in a clear state and also apply a high to gate A21U9A, which turns on and presets the service request flip flop. The Q output of flip flop A21U1A is inverted through gate A21U11D and passed to the controller as a low Service Request (SRQ). At this time the talk electronics is in the SPIS and TIDS state.

4-426. SERIAL POLL MODE STATE (SPMS).

4-427. When the controller receives a SRQ input from the bus, a poll of all devices on the bus is undertaken by the controller to determine the requesting device. This interrogation is started by the controller who moves all devices through the previously described listen handshake cycle. When the bus is moved from the ACRS to ACDS state, the controller places a SPE (serial poll enable) character on the DIO line instead of the listen address and makes ATN then DAV true (low).

4-428. DIO bits 2 through 6 of the SPE character (refer to Table 4-10) are decoded by serial poll decoder A19U3. DIO bits 2, 3 and 6, which are false (2.5V), are inverted twice in PCA A22 and PCA A19 and are applied as highs to gate A19U3. DIO bits 4 and 5 of the SPE character, which are true (0V), are inverted once on PCA A22 and applied to gate A19U3. The output of the serial poll decoder is inverted through gate A21U4C and applied to gate A21U12D in the serial poll enable circuit. DIO bit 1 also is applied to

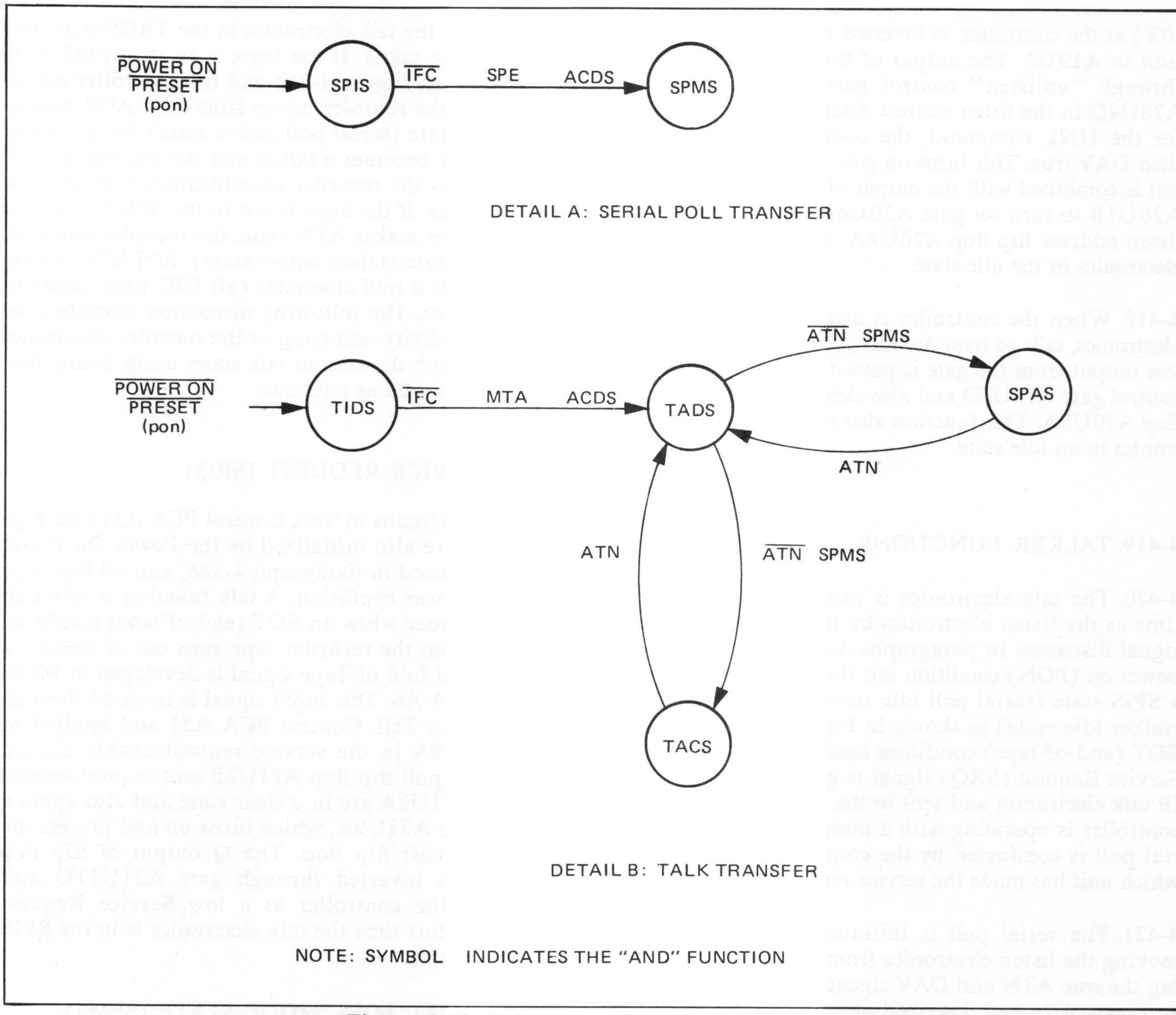


Figure 4-28. Talker Functions, State Diagram

A21U12D. When SPE is on the DIO line, bit 1 is false (2.5V) and arrives at the gate as a high. When the input word is a serial poll disable (SPD), bit 1 is true (0V) and gate A21U12D is disabled.

4-429. In the SPE mode, the output of gate A21U12D is applied to A21U5B. The low ATN and DAV inputs from the controller are inverted on PCA A19 and enables gate A20U5B on the Listen Control PCA. One output of the gate is passed through connector XA20-11 and PCA A19 to the other side of gate A21U5B which turns on and presets serial poll flip flop A21U2B. When flip flop A21U2B presets, the talk electronics is moved from the SPIS to SPMS state as shown in Detail A, Figure 4-28. The output of the flip flop is applied to gate A21U9C, but has no effect at this time.

4-430. TALKER ADDRESSED STATE (TADS).

4-431. After the controller sets all devices into the serial poll mode state, each unit is addressed individually to ascertain which unit made the service request. This address function is accomplished when the controller enables each unit's talk address circuit, and then monitors the DIO lines for the unit response. The recorder address is the ASCII character "Q" with the bit pattern shown in Table 4-10 when the address is set as indicated.

4-432. When the controller is ready to move the recorder from the TIDS to TADS state, the listen electronics is used to perform the short handshake function. As the electronics is moved from ACRS to ACDS, the recorder talk address is placed on the DIO lines. DIO bits 1 through 5 are the same in a recorder talk or listen address as discussed in paragraph 4-400. Address

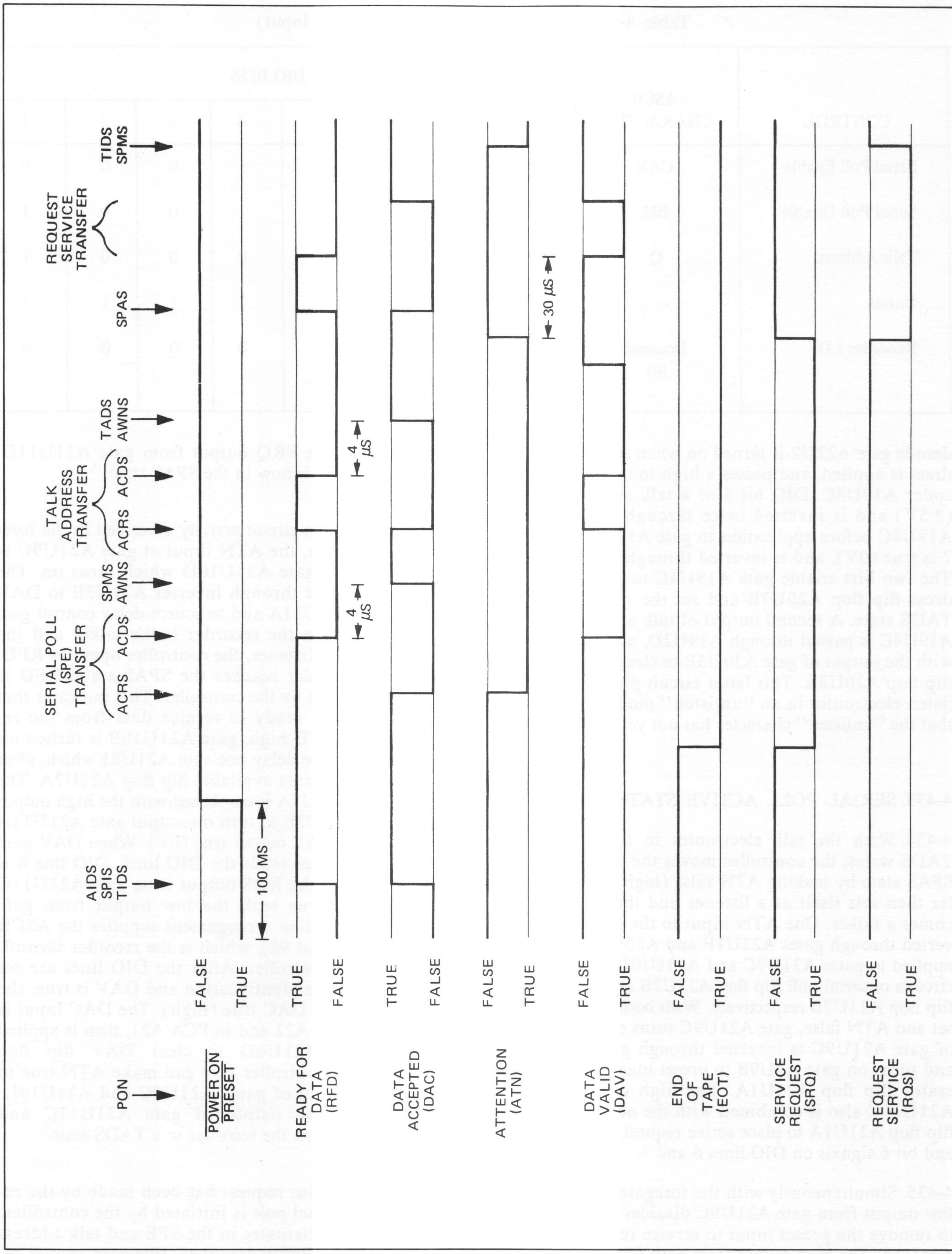


Figure 4-29. HP-IB Talk Function, Timing Diagram

Table 4-10. Talk DIO Bit Patterns (Source Input)

CONTROL	ASCII CHARACTER	DIO BITS							
		8	7	6	5	4	3	2	1
Serial Poll Enable	CAN	X	0	0	1	1	0	0	0
Serial Poll Disable	EM	X	0	0	1	1	0	0	1
Talk Address	Q	X	1	0	1	0	0	0	1
Untalk	--	X	1	0	1	1	1	1	1
Recorder I.D.	Decimal 96	0	1	1	0	0	0	0	0

decode gate A22U2 is turned on when the recorder address is applied, and passes a high to talk address decoder A10U4C. DIO bit 6 of a talk address is false (2.5V) and is inverted twice through A22U1A and A19U8C before application to gate A19U4C. DIO bit 7 is true (0V), and is inverted through gate A22U3F. The two bits enable gate A19U4C to preset talk address flip flop A20U7B and set the recorder in the TADS state. A second output of talk address decoder A19U4C is passed through A19U2D, and is combined with the output of gate A20U5B to clear listen address flip flop A20U8A. This latter circuit places the HP-IB listen electronics in an "unlisten" mode in the event that the "unlisten" character has not yet been sent.

4-433. SERIAL POLL ACTIVE STATE (SPAS).

4-434. With the talk electronics in the SPMS and TADS states, the controller moves the recorder to the SPAS state by making ATN false (high). The controller then sets itself as a listener and the recorder becomes a talker. One ATN input to the recorder is inverted through gates A22U1F and A20U1F, and then applied to gates A21U9C and A21U10D in the output circuits of serial poll flip flop A21U2B and talk address flip flop A21U7B respectively. With both flip flops preset and ATN false, gate A21U9C turns on. One output of gate A21U9C is inverted through gate A21U10C and turns on gate A2U9B to preset identification generator flip flop A21U1A. The high output of gate A21U10C also is combined with the output of preset flip flop A21U1A to place active request service (RQS) and bit 6 signals on DIO lines 6 and 7.

4-435. Simultaneously with the foregoing activity, the low output from gate A21U9C disables gate A21U9A to remove the preset input to service request flip flop A21U2A. The high output from gate A21U10C then is inverted through gate A21U4D to clear the flip flop. This inhibits the SRQ output from gate A21U11D, and the recorder is now in the SPAS state.

4-436. During the circuit activity described in the foregoing paragraph, the ATN input at gate A21U9C is also applied to gate A21U10D which turns on. The output is applied through inverter A21U3E to DAV output gate A21U11A and to source delay control gate A21U10B. When the recorder is the talker and the controller is the listener, the controller operates RFD. When the recorder reaches the SPAS state, RFD is made true (high) by the controller. This indicates that the controller is ready to receive data from the recorder. With RFD high, gate A21U10B is turned on and toggles source delay one-shot A21U81 which, after its delay, clocks data available flip flop A21U7A. The Q output of A21U7A is combined with the high output of inverter A21U3E to turn on output gate A21U11A and make the DAV output true (0V). When DAV goes true, the controller reads the DIO lines. DIO line 6 is true (low) with the RQS output from gate A21U11C and line 7 is true with the low output from gate U21U11B. This line arrangement supplies the ASCII character (decimal 96), which is the recorder identification, to the controller. After the DIO lines are set with the recorder identification and DAV is true, the controller makes DAC true (high). The DAC input is inverted on PCA A22 and in PCA A21, then is applied through gate A21U6D to clear DAV flip flop A21U7A. The controller now can make ATN true to inhibit the output of gates A21U9C and A21U10D. This inhibits the output of gate A21U11C and A21U11B to return the recorder to a TADS state.

4-437. If no service request has been made by the recorder and a serial poll is initiated by the controller, the recorder participates in the SPE and talk address functions as previously described. However, service request flip flop A20U2A remains cleared and keeps gate

A21U9B disabled. This condition inhibits the operation of request-service flip flop A21U1A, and the operation of output gate A21U11B and A21U11C. When the controller makes ATN false the recorder moves to the SPAS state, but the DIO lines from the recorder to controller are all false. The controller determines from this indication that the recorder did not make the service request.

4-438. UNTALK CONTROL.

4-439. After completion of a request service function between the controller and recorder, the controller can place the talk electronics in an idle, or "untalk" state, by one of two methods. The first means is by setting the recorder listen electronics to an addressed state. An input listen address decoded at gate A19U4B whose output contributes to pre-setting listen address flip flop A20U8A. A second output of gate A19U4B is passed to gate A21U12A in Talk Control PCA A21 and, with ATN from the controller high, clears talk flip flop A21U7B.

4-440. The second method of placing the talk electronics in the "untalk" state is by use of an "untalk" command, which is the ASCII character "—" (refer to Table 4-10). DIO bits 1 through 5 are all true when the character is asserted, thus, DIO lines 2, 3 and 4 at address decoder A22U2 are false and the gate output is high. This output is passed to "untalk" decoder A19U4A. DIO bit 6 of the character is false and is inverted twice before application to gate A19U4A, while true bit 7 is inverted once. When gate A19U4A turns on, the output is passed through gate A21U12A and inverter A21U12B to gate A21U6A in the talk address disable circuit. When ATN and DAV are true, as is the case in an address transfer, gate A21U6A becomes active and clears talk address flip flop A21U7B.

4-441. SERIAL POLL DISABLE (SPD).

4-442. When the controller is finished with a serial poll operation, all instruments are taken out of the poll mode by a serial poll disable command, which is the ASCII character "EM" (refer to Table 4-10). The bit pattern is the same as for the SPC character, excepting DIO bit 1. DIO bits 2 through 6 (DIO bit 7 is ignored) are decoded at gate A19U3 which provides an inverted high to gates A21U12D and A21U12C. DIO bit 1 of the character is true (0V) and is inverted before application to gate A21U12C. This enables the gate and, with DAV and ATN true, clears serial poll flip flop A21U12B.

4-443. INTERFACE CLEAR (IFC).

4-444. The interface clear line is used by the controller to return the listen, talk and serial poll electronics to an idle state. This can be done at the end of an operation, or during an operation when a stop is required to correct a program error. When IFC is true (0V), the input clears listen address flip flop A21U8A through gates A20U5A and A20U4A. The high IFC output from A20U5A also is passed through connectors XA20-12 and XA21-9 to clear serial poll flip flop A21U2B and talk address flip flop A20U7B. Another IFC line in PCA A21 also clears RQS flip flop A21U2A and identification generator A21U1A. At the completion of the IFC cycle, all recorder HP-IB electronics is in the on idle state and ready for further instructions.

SECTION V

MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains maintenance and troubleshooting procedures for the Models 3964A and 3968A Instrumentation Tape Recorders. Repair and replacement of parts should not be attempted until it has been determined that the malfunctioning part has been properly adjusted and still does not meet performance specifications. Included herein is a list of test equipment required for maintenance, preventive maintenance procedures, performance tests and adjustment procedures.

5-3. TEST EQUIPMENT.

5-4. Test equipment required for testing and maintaining the recorders is listed in Table 5-1. Test equipment with equivalent characteristics may be used. Recommended accessories are listed in Table 5-2; equivalent accessories may be used.

5-5. PREVENTIVE MAINTENANCE.

5-6. The recorder is so designed that very little maintenance is required. All bearings used are the permanently lubricated type and do not require lubrication. The more important preventive maintenance considerations are: preventing oxide buildup in the transport tape path, keeping the recorder clean, and demagnetizing heads and tape-path components.

5-7. VISUAL INSPECTION.

5-8. A visual inspection of the recorder should be conducted twice a year, and should be inclusive of, but not restricted to the following items:

a. Tape heads, guides, capstan and pinchroller for oxide buildup and excessive wear (refer to Figure 3-14).

b. Damper assembly (see Figure 5-1) for possible oil leaks or mechanical binding (a light oil film is normal). Dampers should return smoothly to upward, relaxed position when released.

c. Loose, worn, or broken hardware.

d. Damaged or burned insulation or printed circuit assemblies.

e. Damaged wires, terminations or solder joints.

f. Mechanical binding or misalignment of the brakes or pinchroller mechanism.

5-9. LUBRICATION.

5-10. The recorder does not require lubrication.

5-11. HEAD, CAPSTAN AND TAPE GUIDE CLEANING.

5-12. Cleanliness of the head, capstan and tape guides is included under Operator Maintenance in Section III. Refer to paragraph 3-93 for these procedures.

5-13. CLEANING BRAKES.

5-14. Keep dirt and tape debris away from the brakes (see Figure 5-1). Be especially careful to prevent oil from contaminating the brake bands. Dirt, tape debris, and oil can enter the brakes through the narrow gap between the reel hub and the deck casting. If necessary, use compressed air to blow out dirt around the brakes. The brakes also can be cleaned with DuPont Freon TF, or equivalent.

CAUTION

Use cleaning agents sparingly in the brake area. Reel hub bearings should not be washed with the cleaner.

5-15. CLEANING SOLENOIDS.

5-16. Solenoid plungers (see Figure 5-1) can accumulate dirt and dust and cause a malfunction. Keep the solenoid plungers clean with DuPont Freon TF, or equivalent.

5-17. INTERNAL CLEANLINESS.

5-18. Periodically remove the side covers and control panel; open the transport and vacuum the interior of the recorder. Loosen any dirt remaining with a soft bristled brush and revacuum, or blow away dust with compressed air. Greasy surfaces should be wiped clean with a cloth moistened with Freon TF (DuPont) or Genesolve-D (Allied Chemical), or equivalent.

Table 5-1. Test Equipment Required

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	INSTRUMENT RECOMMENDED
Flutter Meter	IRIG Standards	Flutter Check	8300 MICOM
Test Oscillator	Frequency Range: 10 Hz to 100 kHz Attenuator Accuracy: ±0.3 dB Output: 1.0 Vrms into 600Ω Dial Accuracy: ±3% Frequency Response: 2% Distortion: Less than 0.1% Hum and Noise: Less than 0.05%	Distortion Check Meter Accuracy Check Frequency Response Check Signal-to-Noise Check Direct Record/Reproduce Adjustment	HP 204D
AC Voltmeter (ACVM)	Frequency Range: 10 Hz to 10 MHz Voltage Range: 1 mV to 30V Linear dB Scale: -10 dB to +2 dB Accuracy: ±2% Input Impedance: 10 megohms	Meter Accuracy Frequency Response Check Signal-to-Noise Check Direct Record/Reproduce Adjustment	HP 427A
Square Wave Generator	Frequency Range: 10 Hz to 10 kHz Amplitude: 5V p-p into open-circuit Output Impedance: 600Ω Rise & Fall Times: <100 ns	Phase Equalizer Check	HP 3311A
Oscilloscope	Dual Trace: 10 mV/cm Bandwidth: DC to 35 MHz Accuracy: ±3% Time Base Range: 0.1 μs/div to 2 s/div	Phase Equalizer Check Bias Oscillator Check Troubleshooting	HP 1700B
Electronic Counter	Frequency Range: 50 MHz	Reference Oscillator Check FM Alignment	HP 5326A
Wave Analyzer	Frequency Range: 15 Hz to 50 kHz Accuracy: ±3 Hz Voltage Range: 100 nV to 30V full scale Voltage Accuracy: ±4%	FM and Direct Distortion	HP 3581A
Digital Multimeter (DMM)	Display 4-1/2 digits DC Voltage Range: ±1V to ±1000V DC Accuracy: ±0.03% rdg., +0.01% rng. AC Voltage Range: 1 Vac to 1000 Vac AC Accuracy: ±0.25% rdg., +0.05% rng.	Power Supply, Calibration, Meter Accuracy Checks	HP 34740A Display & HP 34702A Multimeter
Variac	Output Range: 0 to 140 Vac, 3 or 5A Input: 115 Vac, 50-60 Hz	AC Line Regulation Check Power Supply Ripple Check	Staco E501V General Radio W10MT3W

Table 5-2. Recommended Accessories

DESIGNATION	DESCRIPTION	QUANTITY REQUIRED
HP 10503A	Cable: 4-foot, BNC to BNC	3
HP 1250-0781	Tee: BNC Jack, BNC Plug, BNC Jack	2
HP 10006D	Voltage Divider Probe, 10:1, 10 msec	1
HP 10008B	Direct Probe, 1:1	2
HP 11000A	Cable: Dual banana plug to dual banana plug	1
HP 11003A	Test Leads: 5-foot, dual banana plug to probe and alligator clip	1
HP 10110A	Adapter: Male BNC to dual female banana plugs (binding posts)	1
HP 11001A	Cable: 45-inch, dual banana plug to UG-88C/U BNC male	2
HP 1250-2277	Adapter: Dual banana plug to BNC female	1
HP 03968-60960	Extender Board, Control PCA	1
HP 03968-60965	Extender Board, Data Card Assembly	1
HP 13064A	Tape Degausser	1
HP 9160-0023	Magnetic Head Degausser	1

5-19. CLEANING SWITCHES, CONTROLS, AND POTENTIOMETERS.

5-20. Periodically switches and controls should be checked for solid detent characteristics, damage, or worn contacts. Potentiometers should be examined for satisfactory operation. Marginal components should be replaced. Setscrews holding knobs to shafts should be checked and tightened to prevent loss of knobs or shaft slippage.

5-21. WEAR ON TAPE HEADS.

5-22. Worn tape heads cause changes in operational characteristics. Record sensitivity may change and the upper band edge response in the direct mode will likely change. If your recorder contains Direct Record/Reproduce channels and head wear causes significant change in frequency response, refer to the adjustment procedures in paragraph 5-83.

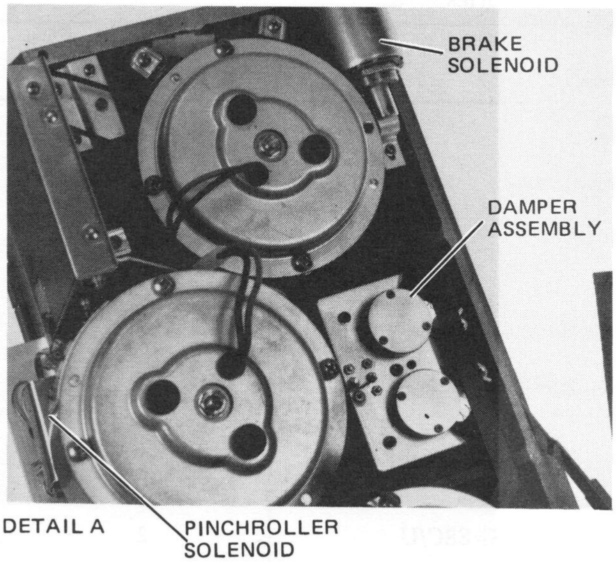
5-23. The record and reproduce heads have been designed and manufactured to provide excellent performance and long life; however, the tape passing over the head presents a relatively rough surface to the head. Since the tape will eventually wear the heads, the only defense against too much wear is a good maintenance program and the use of recommended tape (refer to paragraph 3-7). A poor-quality tape will wear the recorder heads rapidly. Keep the tape-contacting components clean and as free of foreign matter as possible, and use only the approved cleaning solutions for the various components. If in doubt about head wear, contact the nearest Hewlett-Packard Sales and Service Office (listed at the back of this manual).

5-24. DEMAGNETIZING HEADS AND TAPE GUIDE COMPONENTS.

5-25. Degaussing procedures for the recorder are included under Operator Maintenance in Section III. Refer to paragraph 3-97, 3-99 for these procedures.

5-26. OPERATIONAL CHECKOUT PROCEDURES.

5-27. The following paragraphs describe simple checks that can be done without removing the recorder cover. If the recorder response to the checks is satisfactory, there is a high probability that no additional performance checks or calibration adjustments are needed. Complete calibration adjustment procedures are described in later paragraphs.



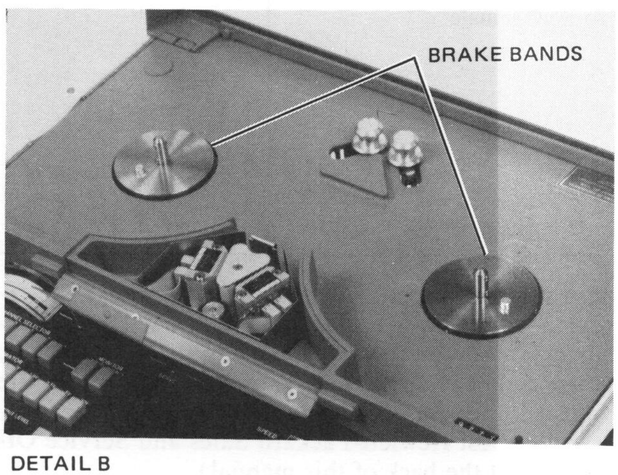


Figure 5-1. Damper, Brakes and Solenoid Identification

NOTE

IT IS IMPORTANT that the heads, capstan, pinchroller and guides be cleaned thoroughly and the tape degaussed prior to performing these tests. If the tape runs out during the procedure, repeat the cleaning and degaussing.

5-28. PRELIMINARY PROCEDURES.

5-29. On the recorder rear panel:

a. Set the FLUTTER COMP switch to OFF.

b. Set the SERVO REFERENCE switch (to the right of the three BNC's) to INTERNAL (lower position).

c. Set the AC VOLTAGE SELECTOR switches to match the available source.

d. Install power cord. Do not connect to source at this time.

5-30. On the front panel:

a. Set the POWER switch OFF.

b. Set the CALIBRATOR to +DC and 0.

c. Set the meter select switch to DC.

d. Set the SERVO switch to TACH.

5-31. TAPE HANDLING CHECK.

a. Load a full reel of degaussed tape on the left.

b. Plug-in the power cord to the source.

c. Set the POWER switch to ON.

d. Observe the following:

1. Power indicator light is on.

2. The 3-3/4 ips (9.52 cm/s) speed pushbutton is lighted.

3. The STOP mode pushbutton is lighted for normal tape tension and goes off after a brief delay for a slack tape.

4. The meter reading is approximately zero on the upper (DC) scale.

e. Apply sufficient tape tension to light the STOP pushbutton.

f. Push the play-forward (>) mode button. The tape should start and within one second the TACH light should go on and remain steady.

g. Push all of the speed buttons in a random sequence, allowing three seconds for the speed to stabilize. In all cases, the TACH light should light and remain steady after this time.

h. Push the fast-forward (>>) mode button. The tape should accelerate rapidly.

i. After about twenty seconds, push the fast-reverse (<<) mode button. The tape should rapidly slow and then accelerate in the reverse direction.

j. Try random changes between these modes. In all cases the tape should be handled smoothly and within a few seconds the TACH light should go on and remain steady.

k. Push the forward button (>), release it, then push the RECORD button. The forward button light should go on and the RECORD button light should not go on. Push buttons simultaneously. Both the forward and RECORD button lamps should go on.

l. Repeat step k. for the play-reverse mode.

NOTE

When in the record-forward mode, pushing any speed, the play-forward, or RECORD buttons should not change the mode. Pushing any other mode button should terminate the record function. The same behavior applies to the record-reverse mode.

m. Push the fast-forward button (>>). After a few seconds switch the POWER to OFF. The brakes should stop the tape smoothly. Switch the POWER to ON. The 3-3/4 ips (9.52 cm/s) speed button and the STOP button lights should both be on.

n. Repeat the test above for 15 ips (38.10 cm/s) forward, reverse and fast-reverse modes. In each case, after power is restored, both the 3-3/4 ips (9.52 cm/s) and STOP button lights should be lighted. Failure of the STOP button to light after these tests indicates that the brakes or end-of-tape (EOT) switches on the damper assembly need adjustment.

o. With the tape running in either direction at several speeds, determine that changing the TACH/TAPE to the TAPE position does not disturb operation.

5-32. FM DATA CHANNEL CHECK.

NOTE

The following procedure assumes that the FM record/reproduce jumpers are connected for normal operation, as the recorder was shipped from the factory. If the jumpers have been changed, they must all be returned to normal before proceeding with the check. Refer to paragraph 3-14 for jumper instructions. The following test sequence will also determine that the meter monitor and calibrator are operative in all modes.

a. Make the following front-panel control settings:

SPEED: 15 ips

MODE: STOP

MONITOR: INPUT

METER: DC

METERED CHANNEL SELECTOR: Desired channel 1-8 with FM PCA installed.

CALIBRATOR: +DC, 0V

OPERATE-CALIBRATE switches: OPERATE

b. Observe meter. Should read approximately 0 on the upper scale and CAL MODE light should be off.

c. On the selected FM channel, set the OPERATE/CALIBRATE to CALIBRATE. The CAL MODE light should go on.

d. Set the CALIBRATOR to 10V and adjust the INPUT LEVEL control of the selected channel to achieve +1 on the upper meter scale.

e. Set the CALIBRATOR to -DC. The meter should read -1 ±0.1.

f. Set the CALIBRATOR to +DC; the MONITOR to OUTPUT; the OUTPUT LEVEL control to achieve +1 on the meter.

g. Set the CALIBRATOR to 5V. The meter should read approximately 0.5.

h. Readjust the INPUT LEVEL to obtain +1 on the meter.

i. Set the CALIBRATOR to 2.5V. The meter should read approximately 0.5.

j. Readjust the INPUT LEVEL to obtain +1 on the meter.

k. Set the CALIBRATOR to 1.4V. The meter should read approximately 0.57.

l. Readjust the INPUT LEVEL to obtain +1 on the meter.

m. Set the CALIBRATOR to 1V. The meter should read approximately 0.71.

n. Set: the meter switch to PK-AC; MONITOR to INPUT; the INPUT LEVEL control to obtain 0 dB on the meter's lower scale.

o. Set the CALIBRATOR to -DC. The meter should read 0 ±0.25 dB.

p. Set the CALIBRATOR to PK-AC. The meter should read 0 ±0.25 dB.

q. Make following connections on front panel (see Figure 5-2):

1. Connect ACVM to OUTPUT MONITOR jack. Set range to 1V (0 dB).

2. Connect test oscillator to EXTERNAL CAL INPUT jack. Set for 500 Hz and output to a convenient level.

r. Make following front panel control settings.

CALIBRATOR: EXT INPUT

SPEED: 15 ips (38.1 cm/s)

MODE: STOP

MONITOR: INPUT

Meter Switch: PK-AC

s. Adjust INPUT LEVEL control of PCA in test for a 0 dB reading on recorder meter.

t. Adjust OUTPUT LEVEL control of PCA in test for a 0 dB reading on ACVM.

u. Start the tape in the RECORD-forward mode. Observe that the ACVM reading remains at 0 dB. Slowly increase the frequency to 5000 Hz and determine that the reading does not change more than ±1 dB.

NOTE

Test results quoted during the performance of steps v. and w. are valid only when type 3M888 Tape, or equivalent, is used.

v. Repeat step u. using the low and high oscillator frequencies listed in Table 5-3. Voltmeter readings should not change more than ±1 dB.

w. Perform the following procedures to check the signal-to-noise ratio.

1. Set the CALIBRATOR to +DC and 0V.

2. Change the ACVM to the 10 mV (-40 dB) range.

3. Set the recorder to forward-RECORD.

4. Select speeds indicated in Table 5-4 and observe ACVM for average dB reading at each speed. Observed value should not exceed (i.e., be more positive than) tabulated value at each speed.

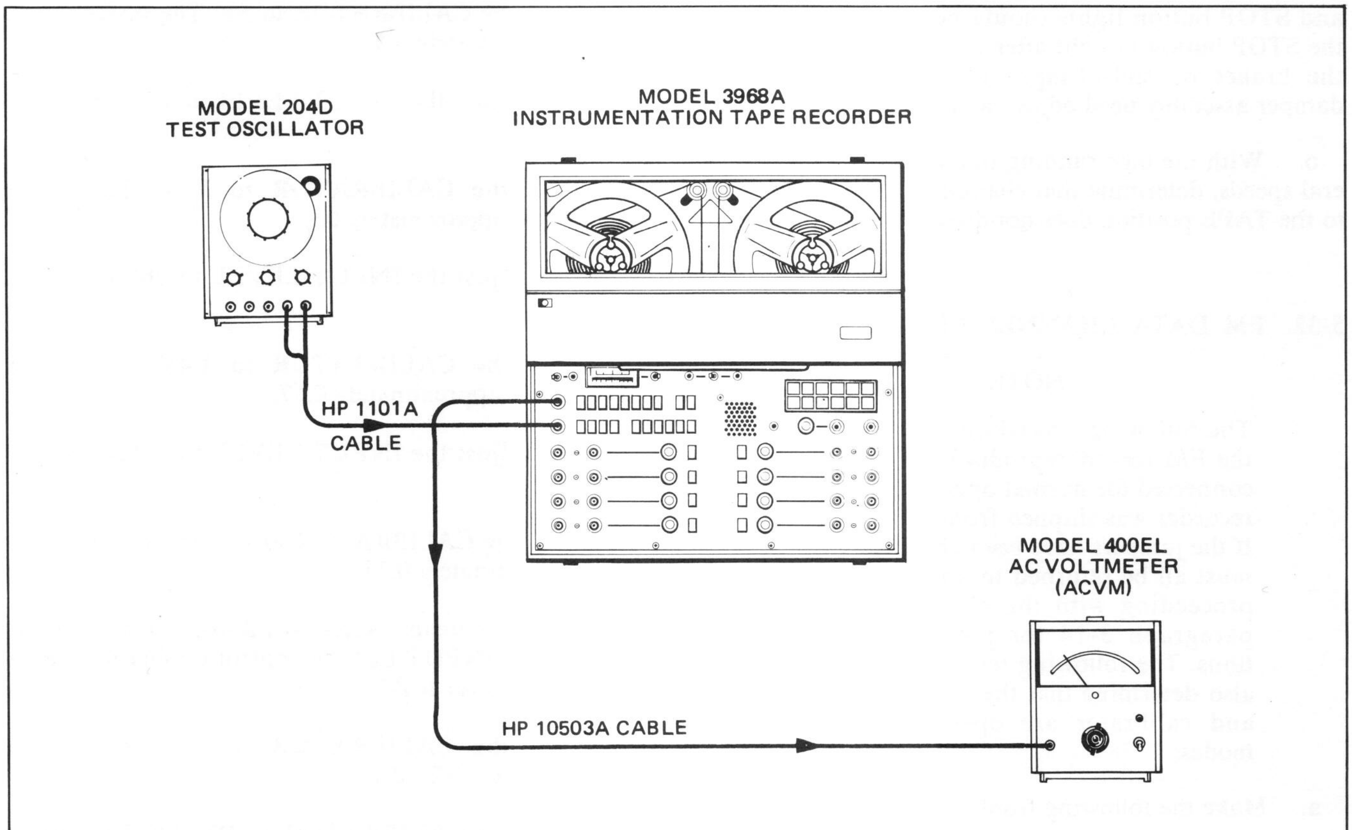


Figure 5-2. FM and DIRECT Test Setup

Table 5-3. Oscillator Settings, FM Passband Test

TAPE SPEED	LOW OSC. FREQUENCY	HIGH OSC. FREQUENCY	PASSBAND (± 1 dB)
15 ips (38.1 cm/s)	500 Hz	5000 Hz	DC – 5 kHz
7-1/2 ips (19.05 cm/s)	250 Hz	2500 Hz	DC – 2.5 kHz
3-3/4 ips (9.52 cm/s)	125 Hz	1250 Hz	DC – 1.25 kHz
1-7/8 ips (4.75 cm/s)	62.5 Hz	625 Hz	DC – 625 Hz
15/16 ips (2.38 cm/s)	31.2 Hz	312 Hz	DC – 312 Hz
15/32 ips (1.19 cm/s)	15.6 Hz	156 Hz	DC – 156 Hz

NOTES: 1. Frequency response over passband is ±1.0 dB referenced to 10% of upper bandedge frequency.
2. As the speed is lowered, the time between reading and playback increases; therefore, frequency changes should be made more slowly.

Table 5-4. FM Signal-To-Noise Ratio Test

TAPE SPEED	S/N RATIO (dB)	
	3964A	3968A
15 ips (38.10 cm/s)	48	46
7-1/2 ips (19.05 cm/s)	48	46
3-3/4 ips (9.52 cm/s)	48	46
1-7/8 ips (4.75 cm/s)	46	46
15/16 ips (2.38 cm/s)	44	44
15/32 ips (1.19 cm/s)	40	40

x. Perform the following procedures to return the FM PCA to the operational condition:

1. Set ACVM to 3V range.
2. Set recorder MODE to STOP.
3. Set recorder SPEED to 15 ips (38.1 cm/s).
4. Set meter switch to PK-AC.
5. Set CALIBRATOR to PK-AC and 2.5V.
6. Set MONITOR selector to INPUT.
7. Adjust PCA INPUT LEVEL control for 0 dB indication on recorder meter.
8. Set MONITOR selector to OUTPUT.
9. Adjust PCA OUTPUT LEVEL control for 0 dB indication.

y. This completes the test for this channel. Select the next FM channel to be tested and push the appropriate CHANNEL SELECTOR button. Repeat steps q. through w. for this channel.

5-33. DIRECT DATA CHANNEL CHECK.

a. Make the following front-panel control settings:

SPEED: 15 ips (38.1 cm/s)

MODE: STOP

MONITOR: INPUT

Meter: PK-AC

METERED CHANNEL SELECTOR: Desired channel 1-8 with direct PCA installed.

CALIBRATOR: PK-AC, 10V

OPERATE-CALIBRATE switches: OPERATE

b. Observe meter. Should read at the left mark on lower scale and CAL MODE light should be off if all channels are in OPERATE mode.

c. On the selected direct channel turn the INPUT LEVEL control fully ccw, then set the OPERATE/CALIBRATE pushbutton to CALIBRATE. The CAL MODE light should go on.

d. Adjust the INPUT LEVEL control to obtain 0 dB on the meter.

e. Set CALIBRATOR to 5V. The meter should read -6 ±0.5 dB.

f. Readjust the INPUT LEVEL control to obtain 0 dB on the meter.

g. Set CALIBRATOR to 2.5V. The meter should read -6 ±0.5 dB.

h. Readjust the INPUT LEVEL control to obtain 0 dB on the meter.

i. Set CALIBRATOR to 1.4V. The meter should read -5 ±0.5 dB.

j. Readjust the INPUT LEVEL control to obtain 0 dB on the meter.

k. Set CALIBRATOR to 1V. The meter should read -3 ±0.5 dB.

l. Make the following connections on front panel.

1. Connect ACVM to OUTPUT MONITOR jack (see Figure 5-2). Set range to 1V (0 dB).

2. Connect test oscillator to EXTERNAL CAL INPUT jack. Set for 1600 Hz and output to a convenient level.

m. Make following front panel control settings:

CALIBRATOR: EXT INPUT

SPEED: 3-3/4 ips (9.52 cm/s)

MONITOR: INPUT

Meter Switch: PK-AC

n. Adjust INPUT LEVEL control of PCA under test for 0 dB reading on recorder meter.

o. Set MODE to forward-RECORD.

p. Adjust OUTPUT LEVEL control of PCA under test for 0 dB reading on ACVM.

q. Decrease oscillator frequency to 100 Hz. ACVM reading should not vary more than ±3 dB.

r. Slowly increase oscillator frequency to 16 kHz. ACVM reading should not vary more than ±3 dB.

s. Set recorder SPEED to 15 ips (38.1 cm/s).

t. Set oscillator frequency to 6400 Hz.

u. Adjust OUTPUT LEVEL control on PCA under test for 0 dB reading on ACVM.

v. Slowly decrease oscillator frequency to 300 Hz. ACVM reading should not vary more than ±3 dB to 500 Hz and not more than ±4 dB to 300 Hz.

w. Slowly increase oscillator frequency to 64 kHz. ACVM reading should not vary more than ±3 dB.

x. Repeat steps a. through w. using the tape speed and oscillator frequencies listed in Table 5-5.

y. Set CALIBRATOR for +DC and 0V.

z. Change ACVM range to 30 mV (-30 dB).

aa. Select speeds indicated in Table 5-6 and observe ACVM for average dB reading at each speed. Observed value should not exceed (i.e., be more positive than) tabulated value at each speed.

ab. Perform the following procedures to return the Direct PCA under test to operational condition:

1. Change ACVM to 1V range.

2. Set recorder MODE to STOP.

3. Set recorder SPEED to 3-3/4 ips (9.52 cm/s).

4. Set meter switch to PK-AC.

5. Set CALIBRATOR to PK-AC and 2.5V.

6. Set MONITOR selector to INPUT.

7. Adjust PCA INPUT LEVEL control for 0 dB indication on recorder meter.

8. Set recorder to forward (>) RECORD.

9. Set MONITOR selector to OUTPUT.

10. Adjust PCA OUTPUT LEVEL control for 0 dB indication.

ac. Repeat steps a. through ab. for all other Direct PCA's installed in the recorder.

5-34. VOICE CHANNEL CHECK.

a. Plug in the microphone and make certain the plug is completely seated. Note the reel counter reading.

b. Set recorder MODE and SPEED for RECORD-forward at 15 ips (38.1 cm/s).

c. Press and hold the microphone press-to-talk pushbutton.

d. Record a few seconds of speech, varying voice loudness to test the automatic volume control (AVC) action.

e. Set the recorder to STOP, then to reverse, and rewind to the starting reel counter value.

Table 5-5. Oscillator Settings, Direct Passband Test

TAPE SPEED	MID OSC. FREQUENCY	LOW OSC. FREQUENCY	HIGH OSC. FREQUENCY	PASSBAND – HZ (± 3 dB)
15 ips (38.1 cm/s)	6.4 kHz	300 Hz	64 kHz	500 – 64,000 (± 4 dB 500–300 Hz)
7-1/2 ips (19.05 cm/s)	3.2 kHz	250 Hz	32 kHz	250 – 32,000
3-3/4 ips (9.52 cm/s)	1.6 kHz	100 Hz	16 kHz	100 – 16,000
1-7/8 ips (4.75 cm/s)	800 Hz	100 Hz	8 kHz	100 – 8,000
15/16 ips (2.38 cm/s)	400 Hz	100 Hz	4 kHz	100 – 4,000
15/32 ips (1.19 cm/s)	200 Hz	100 Hz	2 kHz	100 – 2,000

Table 5-6. Direct Signal-To-Noise Ratio Test

TAPE SPEED	S/N RATIO (dB)
15 ips (38.1 cm/s)	36
7-1/2 ips (19.05 cm/s)	36
3-3/4 ips (9.52 cm/s)	36
1-7/8 ips (4.75 cm/s)	36
15/16 ips (2.38 cm/s)	36
15/32 ips (1.19 cm/s)	35

f. Set recorder to forward, adjusting the VOLUME control for desired volume. The speech should sound clear and intelligible.

g. Repeat the test for each of the remaining speeds, except that it is not necessary to test the AVC action again.

NOTE

The narrow bandwidth of the 15/32 ips (1.19 cm/s) speed noticeably reduces sound quality.

5-35. EXTERNAL SERVO REF INPUT AND TAPE SERVO OPERATION.

a. Connect the counter to the INTERNAL SERVO REF OUTPUT BNC in the rear. Set the speed to 15 ips (38.1 cm/s). Verify that the frequency is 27 kHz ±5.4 Hz (25 kHz ±5.4 Hz with Option 041, IRIG Servo Reference Frequency) (refer to Table 5-7).

b. Successively select the lower speeds and verify that the frequency reduces in octave steps to 843.75 Hz (781.25 Hz for Option 027) ±0.16 Hz at 15/32 ips (11.9 mmps).

c. Connect the square wave generator to the EXTERNAL SERVO REF INPUT BNC. Set its frequency to 3400 Hz. Set its output level to roughly 5V peak-to-peak. Change the Servo Reference Switch to EXTERNAL (the top position).

d. Actuate play-forward and visually observe that the tape moves at roughly 2 ips (5.0 cm/s) at all tape speeds except 15/32 ips. The 15/32 ips speed will divide the tape speed to roughly 1 ips (by a factor of 2).

Table 5-7. Internal Servo Reference Output Frequencies

TAPE SPEED (ips)	(STANDARD) INTERNAL SERVO REF OUTPUT FREQUENCY (Hz)	(OPTION 041) INTERNAL SERVO REF OUTPUT FREQUENCY (Hz)
15	27,000	25,000
7-1/2	13,500	12,500
3-3/4	6,750	6,250
1-7/8	3,375	3,125
15/16	1,687.5	1,562.5
15/32	843.75	781.25

e. Vary the generator frequency slowly over the range from 1200 Hz to 10 kHz on any tape speed from 15/16 ips through 15 ips. The tape speed should change in a corresponding manner. Return the Servo Reference Switch to INTERNAL (bottom position).

NOTE

On instrument which do not have at least one Direct channel, or do not have an FM channel set up for input and output dubbing, it is not possible to check the tape servo mode. If a Direct channel is available, proceed with step f. If an FM channel with input and output dubbing is available, start with step m.

f. Connect a cable between the INTERNAL SERVO REF OUTPUT and the INPUT BNC of the Direct channel. Switch the Direct Channel to OPERATE. With the meter set for PK-AC and the MONITOR INPUT pushbutton engaged, adjust the INPUT control for a reading of +3 dB.

g. Select 15 ips (38.1 cm/s) and set the reel counter to zero. Operate the RECORD-forward pushbuttons.

h. Record for approximately 30 seconds. While recording operate the MONITOR OUTPUT pushbuttons and verify that the output level is 0 ±3 dB on the monitor meter. Stop recorder and note counter reading.

i. Rewind the tape to the zero reel counter position. To reproduce the tape make cable connection between the TAPE SERVO INPUT BNC and the OUTPUT BNC on the Direct PCA being used. Set the SERVO switch to TAPE.

j. Press the forward pushbutton. In a few seconds the TAPE light should go on to indicate phase lock using the recorded tape frequency.

k. Successively select the lower tape speeds and verify that lock can be achieved as indicated by the TAPE light.

l. Verify that the TAPE light goes out and the TACH light is on when the counter reading exceeds that noted in step h.

NOTE

This completes checkout of the tape servo operation with a Direct channel. To check tape servo operation with an FM PCA, the input and output dubbing connections, and the tape servo jumper connection on the FM PCA must be changed. Refer to paragraph 3-39 for these procedures.

m. Connect a cable between the INTERNAL REF OUTPUT jack and the INPUT jack of the FM channel which has been set up for input and output dubbing. Set the Model 3964A or Model 3968A FM PCA INPUT LEVEL control near the OFF position, but not into the off detent.

n. Select 15 ips (38.1 cm/s) and set the reel counter to zero. Press the RECORD and forward pushbuttons.

o. Record for approximately 30 seconds. Stop recorder and note counter reading.

p. Rewind the tape to the zero reel counter position. To reproduce the tape make cable connection between the TAPE SERVO INPUT jack and the OUTPUT jack on the FM channel. Set the SERVO switch to TAPE.

q. Press the forward pushbutton. In a few seconds the TAPE light should go on to indicate speed lock off tape.

r. Successively select the lower tape speeds and verify that lock can be achieved as indicated by the TAPE light.

s. Verify that the TAPE light goes out and the TACH light is on when the counter reading exceeds that noted in step o.

5-36. PERFORMANCE TESTS.

5-37. The following series of tests are intended to verify that the performance of the recorder meets specifications. It is assumed that there are no operational problems. Certain specifications, such as calibrator accuracy, can only be determined by opening the instrument and removing one or more assemblies as during the calibration procedures. Removal procedures will accompany the instructions.

NOTE

It is important that the heads, capstan, pinchroller, and guides be cleaned thoroughly and degaussed prior to performing these tests (refer to paragraph 3-95 through 3-99). Load the instrument with a degaussed reel of the tape for which the recorder was calibrated. If the tape runs out during the performance of the procedures, repeat the cleaning and degaussing. Most specifications are very dependent upon the kind of tape used. Where specification values are given, they presume the use of recommended instrument grade tape. For other kinds of tape, substitute the appropriate values where they exist.

5-38. PRELIMINARY PROCEDURES.

5-39. Perform Meter and Calibration Accuracy Test (see paragraph 5-63).

5-40. Perform the following set up steps:

a. Set the FLUTTER COMP switch to OFF.

b. Set the SERVO REFERENCE switch (to the right of the three BNC's) to INTERNAL (lower position).

c. Set the POWER switch to AC.

d. Set the AC VOLTAGE SELECTOR switch to match the source.

e. Check that the AC FUSE has the correct rating for the selected voltage.

f. Install the line cord.

g. Set the POWER switch to OFF.

h. Set the meter mode switch to PK-AC.

i. Set the SERVO switch to TACH.

j. Load the tape, full reel on the left.

5-41. REFERENCE OSCILLATOR ACCURACY TEST.

a. Connect counter to the INTERNAL SERVO REF OUTPUT jack on rear panel.

b. Set the POWER switch ON.

c. Allow a few minutes warm-up.

d. Select 15 ips (38.1 cm/s) speed.

e. Verify that the counter indicates 27 kHz ±0.0054 kHz (25 kHz ±0.005 kHz with Option 041, IRIG Servo Reference Frequency).

5-42. TAPE SPEED ACCURACY TEST. The recorder has been designed with precision control of tape speed with the reference oscillator (±0.02% frequency tolerance) controlling the capstan in an optical tachometer feedback phase lock servo system. Errors caused by capstan diameter and tape tension variations are minimized by the use of the highest quality components and exacting manufacturing tolerances.

5-43. Tape Speed Accuracy tests are normally accomplished only under carefully controlled laboratory conditions. They are very time consuming and expensive to accomplish to within the accuracy required to verify the specification. For field testing a verification of the following will insure that the tape speed is correct:

a. Reference Oscillator Accuracy Test (paragraph 5-41).

b. Flutter Measurement Test (paragraph 5-44).

c. Timebase Error (TBE) Measurement Test (paragraph 5-46).

NOTE

Tape Servo is recommended for the user who records on one recorder and reproduces on another. The Tape Servo feature will insure optimum quality of reproduction by nulling out differences between recorders which contribute toward the ±.2% Tape Speed Accuracy variation.

5-44. FLUTTER MEASUREMENT TEST.

NOTE

If the recorder has only FM channels, then no check of flutter is practical. The principal effect of flutter on FM data is to degrade the signal-to-noise ratio. Therefore, the FM SNR tests listed in paragraph 5-55 will suffice to verify FM flutter performance.

5-45. If there are one or more Direct channels, the following procedures are used to check flutter:

NOTE

The following test sequence should be performed in its entirety at the beginning, middle and end of the tape.

a. Connect the flutter meter TEST FREQUENCY OUTPUT to the INPUT jack of the selected Direct PCA (see Figure 5-3).

b. Connect the OUTPUT of the Direct channel to the TEST FREQUENCY INPUT of the flutter meter.

c. On the recorder make the following control settings:

1. Set the meter mode switch to PK-AC.

2. Set the MONITOR to INPUT.

3. Select the direct channel being used for the test using the METERED CHANNEL SELECTOR pushbutton.

4. Switch the POWER ON.

5. Select 15 ips (38.1 cm/s).

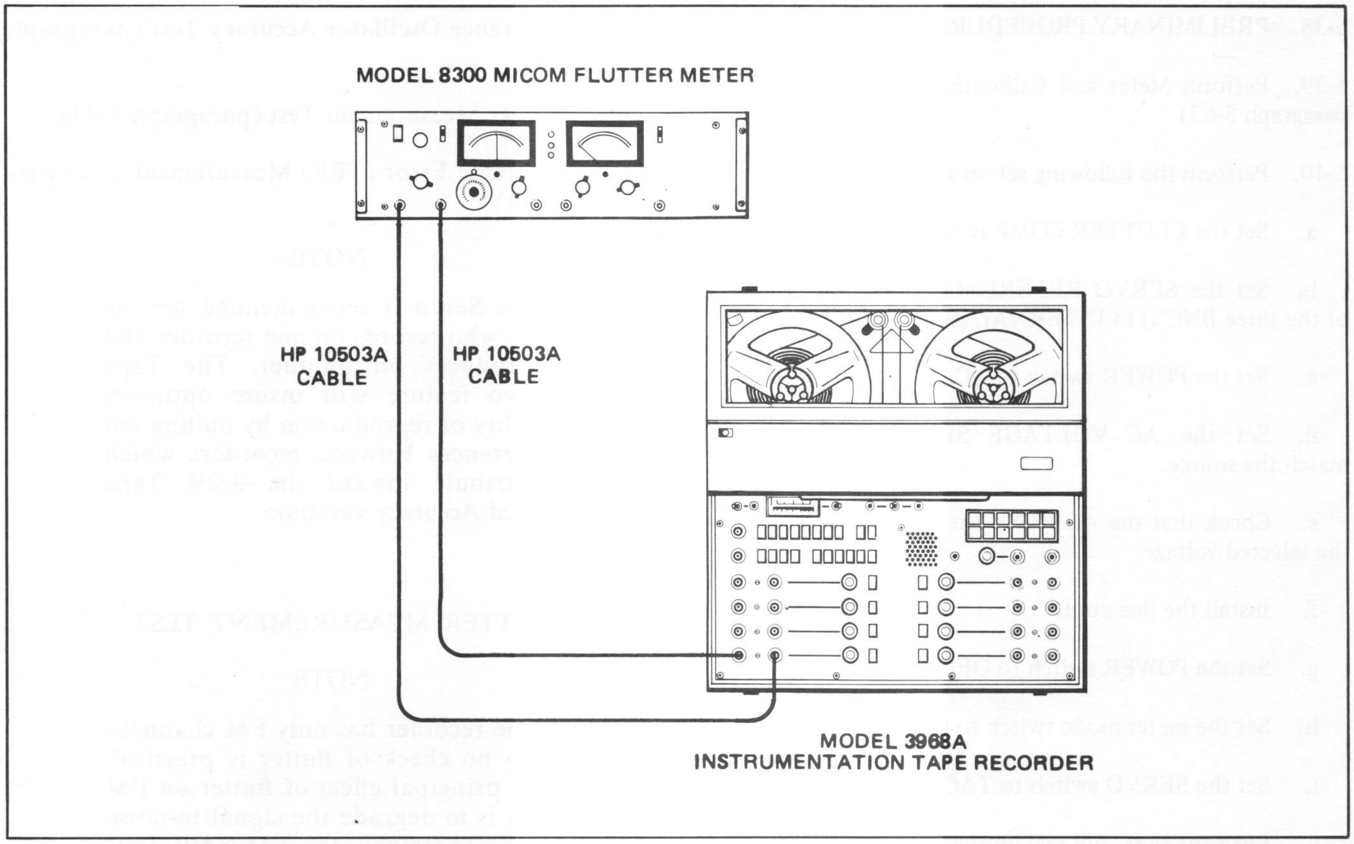


Figure 5-3. Flutter Test Setup

d. On the flutter meter make the following control settings:

1. Set the flutter meter PK-TIME to 2 (sigma).

2. Set the TEST FREQUENCY to 27 kHz.

3. Set the FLUTTER BANDWIDTH to 2.5 kHz.

4. Set the FLUTTER PEAK-TO-PEAK to 1%.

e. Make the following control settings on the recorder:

1. Adjust the INPUT LEVEL control on the Direct channel to obtain +3 dB on the meter.

2. Press the RECORD-forward pushbuttons.

3. Press the reel revolution counter reset button.

4. Set the MONITOR to OUTPUT.

5. Adjust the OUTPUT LEVEL on the Direct channel to obtain approximately -5 dB on the meter.

6. Stop the tape after recording for approximately two minutes. Note the reel revolution counter reading.

7. Rewind the tape back to the 0000 counter reading.

8. Press the forward pushbutton.

f. Measure the flutter on the flutter meter. It should be within the limit given in Table 5-8.

g. When the reel revolution counter again indicates the reading noted in step e.6., stop the tape.

Table 5-8. Flutter Limits
(Recommended Instrumentation Tape)

TAPE SPEED (ips)	FLUTTER (% P-P)
15	0.35
7-1/2	0.35
3-3/4	0.40
1-7/8	0.50
15/16	0.70
15/32	1.50

h. Repeat the procedures of steps m. through u. for each of the remaining speeds (refer to Table 5-9). Use the 3% flutter range for 15/32 ips (1.19 cm/s).

5-46. TIME-BASE ERROR (TBE) MEASUREMENT TEST.

NOTE

If the recorder has only FM channels, then no test of TBE can be made unless one FM data channel is jumpered for both input and output dubbing. However, TBE has little significance for FM and the test may be eliminated.

5-47. The following steps assume use of a Direct channel. If an FM channel with input and output dubbing is used, all references to the monitor meter and input level adjustment are to be ignored.

NOTE

The following test sequence should be performed in its entirety at the beginning, middle and end of the tape.

a. Load the degaussed tape onto the machine.

b. Connect the INTERNAL SERVO REF OUTPUT to the data PCA INPUT jack.

c. Set the meter mode switch to PK-AC.

d. Set the MONITOR to INPUT.

e. Select the channel being used for test using the METERED CHANNEL SELECTOR pushbutton.

f. Switch the POWER ON.

g. Select 15 ips (38.1 cm/s).

Table 5-9. Flutter Test Frequencies and Bandwidths

TAPE SPEED (ips)	TEST FREQUENCY (kHz)	BANDWIDTH (kHz)
15	27	2.5
7-1/2	13.5	1.25
3-3/4	6.75	.625
1-7/8	3.38	.313
15/16	1.69	.156[1]
15/32	1.69	.078[1]

[1]Most flutter meters do not provide bandwidths lower than 0.313 kHz. Use a bandwidth of 0.313 during these measurements. This bandwidth will degrade the measured flutter slightly.

h. Adjust the PCA INPUT LEVEL control to obtain +3 dB on the meter.

i. Press the RECORD and forward pushbuttons.

j. Press the reel revolution counter reset button.

k. Stop the tape after recording for approximately three minutes. Note the reel revolution counter reading.

l. Rewind the tape back to the 0000 counter reading.

m. Connect the INTERNAL SERVO REF OUTPUT jack on rear panel to the External Trigger Input of the oscilloscope (see Figure 5-4).

n. Using a "T" connector, connect the data PCA OUTPUT jack to the TAPE SERVO INPUT jack on rear panel, and also to the Vertical Input of the oscilloscope.

o. Set the SERVO switch on the front panel to TAPE (it may be left in this position for recording as well).

p. Press the forward pushbutton. In a few seconds the TAPE light on the front panel should go on to indicate phase lock off tape.

q. Adjust the oscilloscope time base and trigger to display a single leading edge with the TBE component occupying a minimum of 1 cm horizontally.

r. Set the vertical sensitivity to approximately .2 V/div.

s. Adjust the scope intensity to a level which prevents trace blooming but still displays individual transient excursions, see Figure 5-5.

t. Observe the CRT display for several seconds.

u. Convert the TBE displayed on the oscilloscope to units of time based upon the horizontal width of the solid portion of the display. Ignore crossovers occurring not more than 5% of the time.

v. Stop the tape.

w. Divide the peak-to-peak TBE found in step u. by two and compare this peak value with that listed in Table 5-10.

x. Rewind the tape back to the 0000 counter reading.

y. Repeat steps p. through x. for each of the remaining speeds.

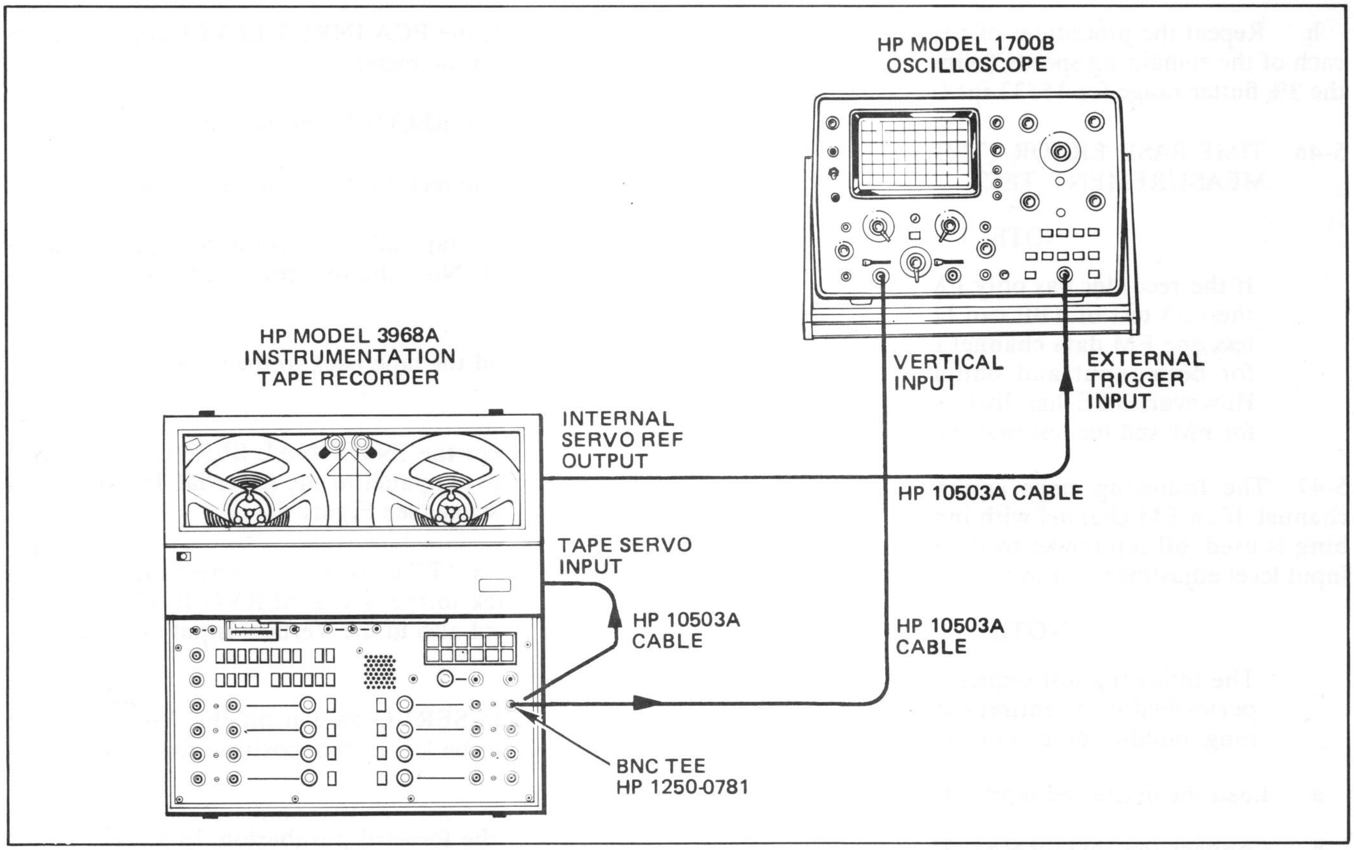


Figure 5-4. Time Base Error Test Setup

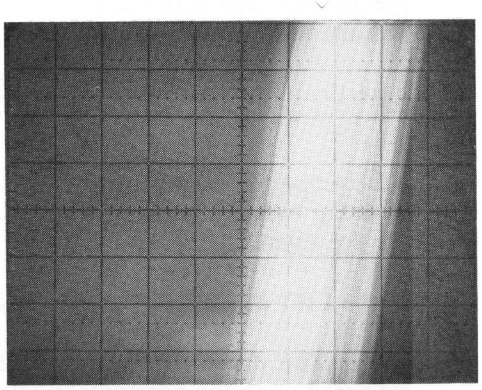


Figure 5-5. Time Base Error Oscilloscope Presentation

Table 5-10. Time Base Error (TBE) Limits (Recommended Instrumentation Tape)

TAPE SPEED (ips)	TBE (μs)
15	± 4.0
7-1/2	± 5.0
3-3/4	± 7.5
1-7/8	±15.0
15/16	±25.0
15/32	±50.0

5-48. FM RECORD/REPRODUCE TESTS.

5-49. It is assumed for these tests that the FM channels are set up for bipolar operation. If any channels are not, it is more convenient to remove the PCA, change the jumpers to bipolar operation (see Figure 3-5), readjust zero (refer to paragraph 5-77) and re-install. At the completion of the tests, the unipolar operation may be restored.

NOTE

Ideally an FM channel should give zero DC output for a zero input signal. However, the zero output may be sufficiently large enough to require readjustment before starting these tests. Note that zero offset is not a specified parameter, and that it normally varies

with the selected speed; therefore, re-adjustment may be necessary if various speeds are used during the test.

a. Switch the POWER ON and allow five minutes, or more, warm-up.

b. Select 15 ips (38.1 cm/s) speed.

c. Set the meter mode switch to DC.

d. Select the FM channel being used for test using the METERED CHANNEL SELECTOR pushbutton.

e. Set the MONITOR to INPUT.

f. Set the CALIBRATOR for +DC and 10V.

g. Set the OPERATE/CALIBRATE switch on the data PCA to CALIBRATE.

h. Adjust the INPUT LEVEL control to obtain +1 on the meter's upper scale.

i. Set the MONITOR to OUTPUT.

j. Set the PCA OUTPUT LEVEL control to obtain +1 on the meter.

k. Change the CALIBRATOR to 0V.

l. Connect the digital multimeter (set for 10 VDC) to the PCA OUTPUT jack (see Figure 5-6).

m. Observe the DMM reading. If the magnitude of the output is 100 mV or more, remove the control panel and adjust the ZERO trimmer on the PCA to obtain 0V ±0.005V.

n. Repeat steps d. through m. for all FM channels.

5-50. FM LINEARITY TEST.

NOTE

It is not necessary to run tape for this test.

a. Switch the POWER ON and allow a few minutes warm-up.

b. Select 15 ips (38.1 cm/s).

c. Set the meter mode switch to PK-AC.

d. Connect the data channel being tested to the meter using the associated METERED CHANNEL SELECTOR pushbutton.

e. Set the MONITOR selector for INPUT.

f. Set the CALIBRATOR for +DC and 10V.

g. Set the OPERATE/CALIBRATE switch on the data PCA to CALIBRATE.

h. Adjust the PCA INPUT LEVEL control to obtain a 0 dB reading on the meter's lower scale.

i. Set the MONITOR selector for OUTPUT.

j. Set the PCA OUTPUT LEVEL control to obtain a 0 dB reading on the meter.

k. Change the CALIBRATOR to 0V.

l. Connect the digital multimeter (set on the 10 VDC range) to the PCA OUTPUT jack (see Figure 5-6).

m. Note the DMM reading, including polarity. This is the offset voltage.

n. Change the CALIBRATOR to 10V and note the DMM reading.

o. Change the CALIBRATOR to -DC and note the reading.

p. Subtract the offset voltage from the voltage found in step n. to obtain the positive output change.

q. Subtract the offset voltage from the voltage found in step o. to obtain the negative output change.

r. Sum the voltages obtained in step p. and q. to obtain the linearity error voltage; maximum allowable 0.050V.

Example:

step m. voltage = -0.009

step n. voltage = +2.513

step o. voltage = -2.497

step p. voltage = +2.513 -(-.009) = +2.522

step q. voltage = -2.497 -(-.009) = -.2497

step r. voltage = +2.522 -2.488 = 0.034

s. Repeat these steps for all FM channels.

5-51. FM FREQUENCY RESPONSE TEST.

5-52. Frequency response is the output amplitude of the record/reproduce system when the input is a constant-amplitude signal varying in frequency. The response is measured and specified in dB relative to the output level obtained at one-tenth the upper band edge frequency. An amplitude-phase selector jumper (see Figure 3-5) is provided on the FM PCA to select either flat frequency response (jumper between pins "C" and "A") or minimum overshoot (jumper between "C"

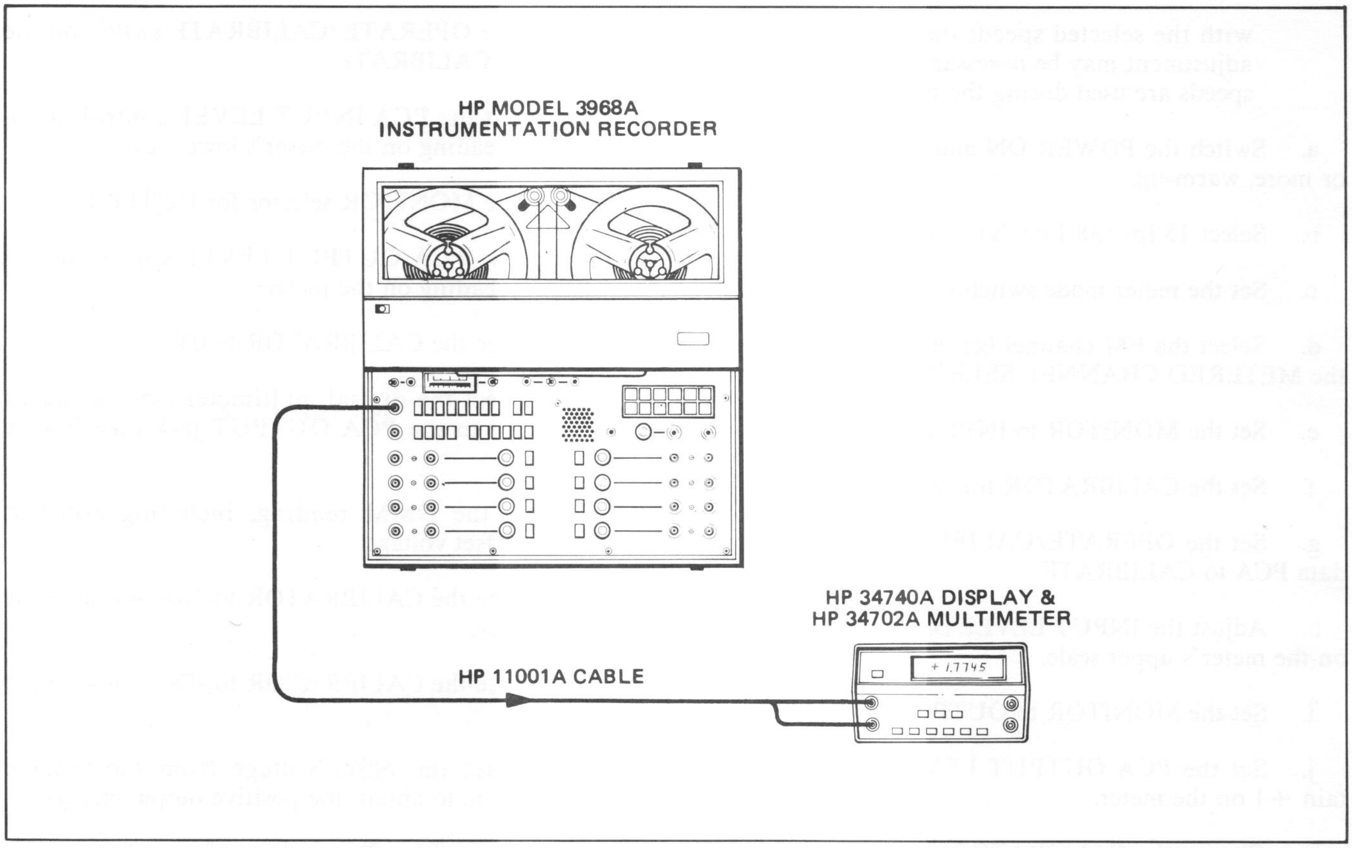


Figure 5-6. FM Zero and Linearity Test Setup

and "Ø"). The response is specified only for the amplitude connection. Make the proper jumper connection and test the FM frequency response as follows:

a. Load the degaussed tape onto the machine.

b. Switch the POWER ON.

c. Select 15 ips (38.1 cm/s) speed.

d. Set the meter mode switch to PK-AC.

e. Set the MONITOR selector for INPUT.

f. Connect the data channel being tested to the meter using the associated METERED CHANNEL SELECTOR pushbutton.

g. Connect the test oscillator to EXTERNAL CAL INPUT jack on the front panel. Set its frequency to 500 Hz and its output level to a convenient value, constant for the tests (see Figure 5-7).

h. Connect the ACVM to the OUTPUT MONITOR jack on the front panel. Set it to the 1V (0 dB) range.

i. Set the CALIBRATOR to EXT INPUT.

j. Set the data PCA OPERATE/CALIBRATE switch to CALIBRATE.

k. Adjust the PCA INPUT LEVEL control to obtain 0 dB on the internal meter.

l. Adjust the PCA OUTPUT LEVEL control to obtain 0 dB on the ACVM.

m. Press the RECORD and forward pushbuttons. Slowly increase the test oscillator frequency while observing the ACVM reading. The reading must not change more than ±1 dB up to 5000 Hz.

n. Stop the tape.

o. For each of the remaining speeds, check the response over the ranges given in Table 5-11 to determine that they do not exceed the ±1 dB limit.

p. Repeat these steps for all FM channels.

5-53. FM DISTORTION TEST.

5-54. The following procedure is used to measure harmonic distortion in the FM record/reproduce system. The distortion in an FM system is dependent upon signal frequency and reaches its maximum when the fundamental is at half the channel bandwidth. For this reason, only the half-band edge frequency second harmonic component is normally measured. An alternative procedure is also provided for determining total harmonic distortion (THD) at other fundamental frequencies.

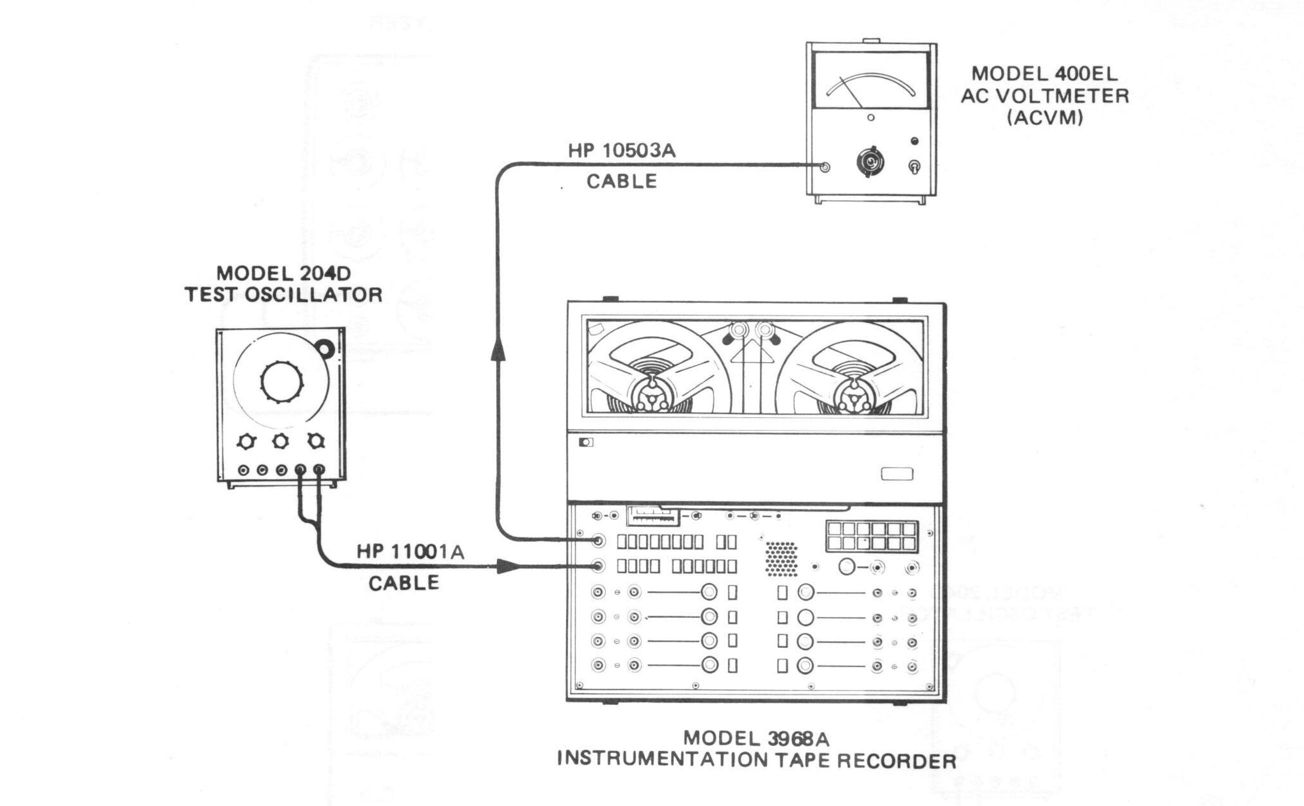


Figure 5-7. FM Frequency Response Test Setup

Table 5-11. Distortion Test Frequencies and Limits

TAPE SPEED (ips)	TEST FREQUENCY (Hz)	SECOND HARMONIC (Hz)	LIMIT (%)
15	2500	5000	1.2
7-1/2	1250	2500	1.2
3-3/4	625	1250	1.2
1-7/8	312	625	1.2
15/16	156	312	2.0
15/32	78	156	2.0

a. Load the degaussed tape onto the machine.

b. Switch the POWER ON.

c. Select 15 ips (38.1 cm/s) speed.

d. Set the meter mode switch to PK-AC.

e. Set the MONITOR selector for INPUT.

f. Connect the data channel being tested to the front-panel meter using the associated METERED CHANNEL SELECTOR pushbutton.

g. Connect the test oscillator to EXTERNAL CAL INPUT jack on the front panel. Set its frequency to 2500 Hz and its output level to a convenient value, constant for the tests (see Figure 5-8).

h. Connect the wave analyzer to the OUTPUT MONITOR jack on the front panel.

i. Set the CALIBRATOR to EXT INPUT.

j. Set the data PCA OPERATE/CALIBRATE switch to CALIBRATE.

k. Adjust the PCA INPUT LEVEL control to obtain 0 dB on the front panel meter.

l. Adjust the wave analyzer for the desired reference level at the fundamental frequency.

m. Tune the wave analyzer to the second harmonic at 5000 Hz.

n. Press the RECORD and forward pushbuttons.

o. Measure the percentage magnitude of the second harmonic. The value must not exceed the limit listed in Table 5-11.

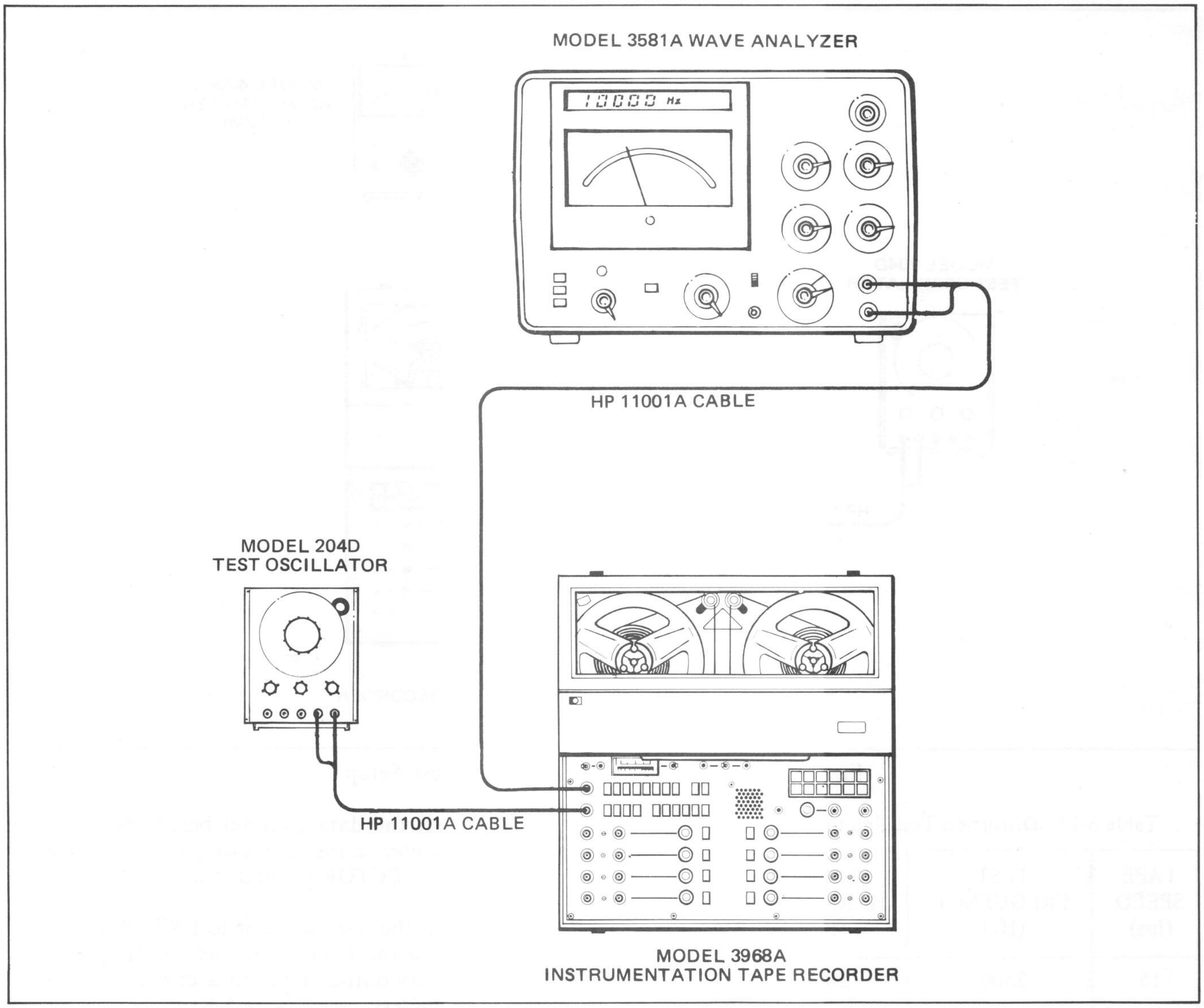


Figure 5-8. FM Distortion Test Setup

p. Stop the tape.

q. Repeat steps l. through p. for each of the remaining speeds, selecting the test frequencies and distortion limits from Table 5-11.

r. Repeat these steps for all FM channels.

s. If it is desired to verify the THD at any other frequency (usually lower than half-band edge) follow the steps below.

NOTE

The THD in percent is defined by the equation:

$$\text{THD} \equiv \sqrt{\frac{a_2{}^2 + a_3{}^2 + \cdots + a_n{}^2}{a_1{}^2}} \times 100\%$$

where:
a_1 = amplitude of the fundamental
a_2 = amplitude of the second harmonic
a_3 = amplitude of the third harmonic
a_n = amplitude of the n-th harmonic

Using the method above which measures the harmonic amplitude as a percentage of the fundamental, a simpler form may be used:

$$\text{THD (\%)} \equiv \sqrt{b_2{}^2 + b_3{}^2 + \cdots + b_n{}^2}$$

where:
b_2 = percent second harmonic
b_3 = percent third harmonic
b_n = percent n-th harmonic

t. Select a desired fundamental frequency.

u. Follow the procedure above to find b_2, b_3, etc. It is generally not useful to measure harmonics higher than the third.

5-55. FM SIGNAL-TO-NOISE RATIO (SNR) TEST.

5-56. FM signal-to-noise ratio is a measure of record/reproduce system noise. It includes the effects of tape flutter and is measured in dB below full signal (±40% deviation).

a. Switch the POWER ON.

b. Select 15 ips (38.1 cm/s) speed.

c. Set the meter mode switch to PK-AC.

d. Set the MONITOR selector for INPUT.

e. Connect the data channel being tested to the front-panel meter using the associated METERED CHANNEL SELECTOR pushbutton.

f. Connect the ACVM to the OUTPUT MONITOR jack on the front panel. Use the 0 dB (1V) range on the ACVM (see Figure 5-9).

g. Set the CALIBRATOR for PK-AC, 2.5V.

h. Set the data PCA OPERATE/CALIBRATE switch to CALIBRATE.

i. Adjust the PCA INPUT LEVEL control to obtain 0 dB on the internal meter.

j. Adjust the PCA OUTPUT LEVEL to obtain 0 dB on the ACVM.

k. Set the CALIBRATOR to 0V.

l. Set the ACVM to the -40 dB (10 mV) range.

m. Actuate record-forward and observe the average minus dB reading of the noise. This minus dB reading is the positive SNR and must not be less than (a more positive meter reading) the value listed in Table 5-4.

n. Select each of the remaining speeds and determine that the SNR is at least as high at the value listed in the table for each speed.

o. Repeat the test above for each of the remaining FM channels.

5-57. DIRECT RECORD LEVEL TEST.

5-58. In a direct record/reproduce system there is a trade-off between distortion and signal-to-noise ratio (SNR) as the record level is varied. The record current is therefore set at the highest level which gives acceptable distortion for some reference condition. For the recorder, that reference condition is the third harmonic distortion of a 500 Hz fundamental at a tape speed of 3-3/4 ips (9.52 cm/s). If the distortion measured below exceeds tolerance, it will be necessary to remove the control panel and readjust the REC trimmer on the PCA. If the distortion is much less than allowable, SNR can be improved by readjusting the REC trimmer. Adjustment of this trimmer to achieve the correct distortion will not affect frequency response. The record level test is conducted as follows:

a. Load the degaussed tape onto the machine.

b. Switch the POWER ON.

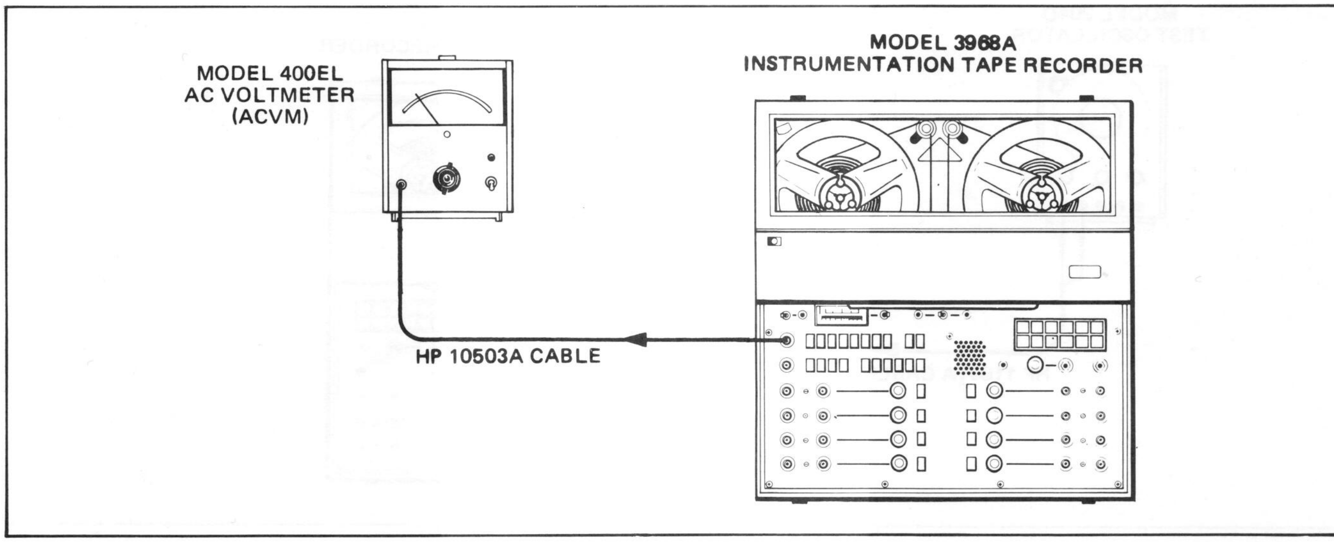


Figure 5-9. FM Signal-To-Noise Ratio Test Setup

c. Set the meter mode switch to PK-AC.

d. Set the MONITOR selector for INPUT.

e. Connect the data channel being tested to the front-panel meter using the associated METERED CHANNEL SELECTOR pushbutton.

f. Connect the test oscillator to the front panel EXTERNAL CAL INPUT jack. Set its frequency to 500 Hz and its output level to a convenient value (see Figure 5-10).

g. Connect the wave analyzer to the front panel OUTPUT MONITOR jack.

h. Set the CALIBRATOR for EXT INPUT.

i. Set the data PCA OPERATE/CALIBRATE switch to CALIBRATE.

j. Adjust the PCA INPUT LEVEL control to obtain 0 dB on the meter.

k. Set the unit for RECORD and forward at 3-3/4 ips (9.52 cm/s) speed.

l. Adjust the wave analyzer for the desired reference level at the fundamental frequency of 500 Hz.

m. Tune the wave analyzer to the third harmonic at 1500 Hz. Measure the amplitude at this frequency. There is typically some fluctuation in this reading, but the average reading should be -40 ±2 dB below the reference level. This corresponds to 1% third harmonic distortion.

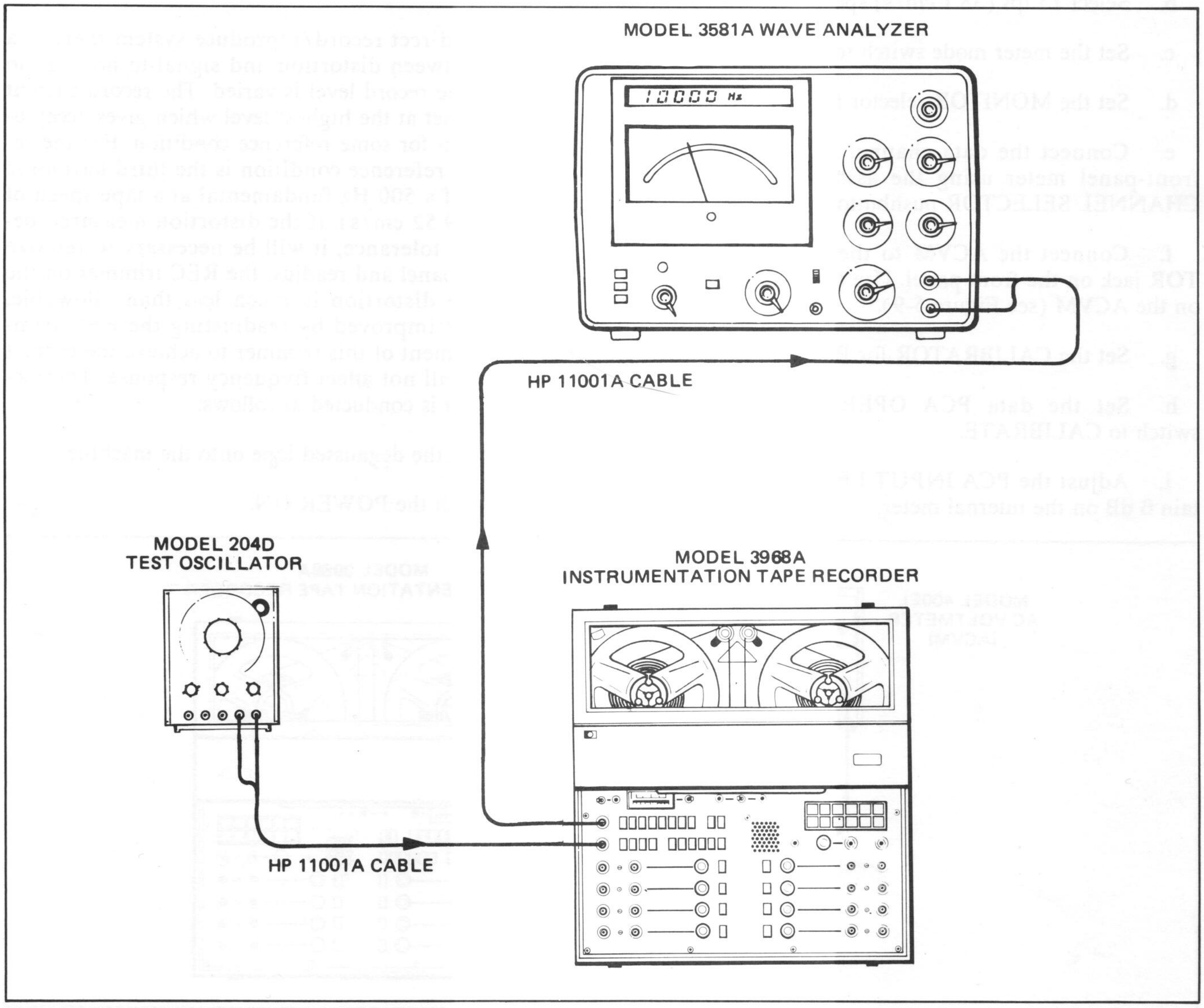


Figure 5-10. Direct Record Distortion Test Setup

5-59. DIRECT FREQUENCY RESPONSE TEST.

5-60. Frequency response is the output amplitude of the record/reproduce system when the input is a constant amplitude signal varying in frequency. The response is measured and specified in dB relative to the output level obtained at 1/10 the upper band edge frequency. The frequency response test is conducted as follows:

a. Load the degaussed tape onto the machine.

b. Switch the POWER ON.

c. Set the meter mode switch to PK-AC.

d. Set the MONITOR selector for INPUT.

e. Connect the data channel being tested to the front panel meter using the associated METERED CHANNEL SELECTOR pushbutton.

f. Connect the test oscillator to the front panel EXTERNAL CAL INPUT jack. Set its frequency to 6400 Hz and its output level to a convenient value, constant for the test (see Figure 5-11).

g. Connect the ACVM to the front panel OUTPUT MONITOR jack. Set its range to +10 dB (3V).

h. Set the CALIBRATOR to EXT INPUT.

i. Set the data PCA OPERATE/CALIBRATE switch to CALIBRATE.

j. Select 15 ips (38.1 cm/s).

k. Adjust the PCA INPUT LEVEL control to obtain 0 dB on the front panel meter.

l. Press RECORD and forward pushbuttons. Adjust PCA OUTPUT LEVEL control for a reading of 0 dB on the ACVM.

m. Slowly increase the test oscillator frequency up to 64 kHz while observing the ACVM reading in dB. The response must not vary more than ±3 dB from the reference level.

n. Similar, vary the frequency down to 500 Hz. The response must not vary more than ±3 dB.

o. Vary the frequency down to 300 Hz. The response must not vary more than ±4 dB.

NOTE

In a similar manner, test each of the other speeds in turn, first noting as the reference level the output at 1/10 the upper band edge frequency. Determine that the response does not vary more than ±3 dB relative to the reference

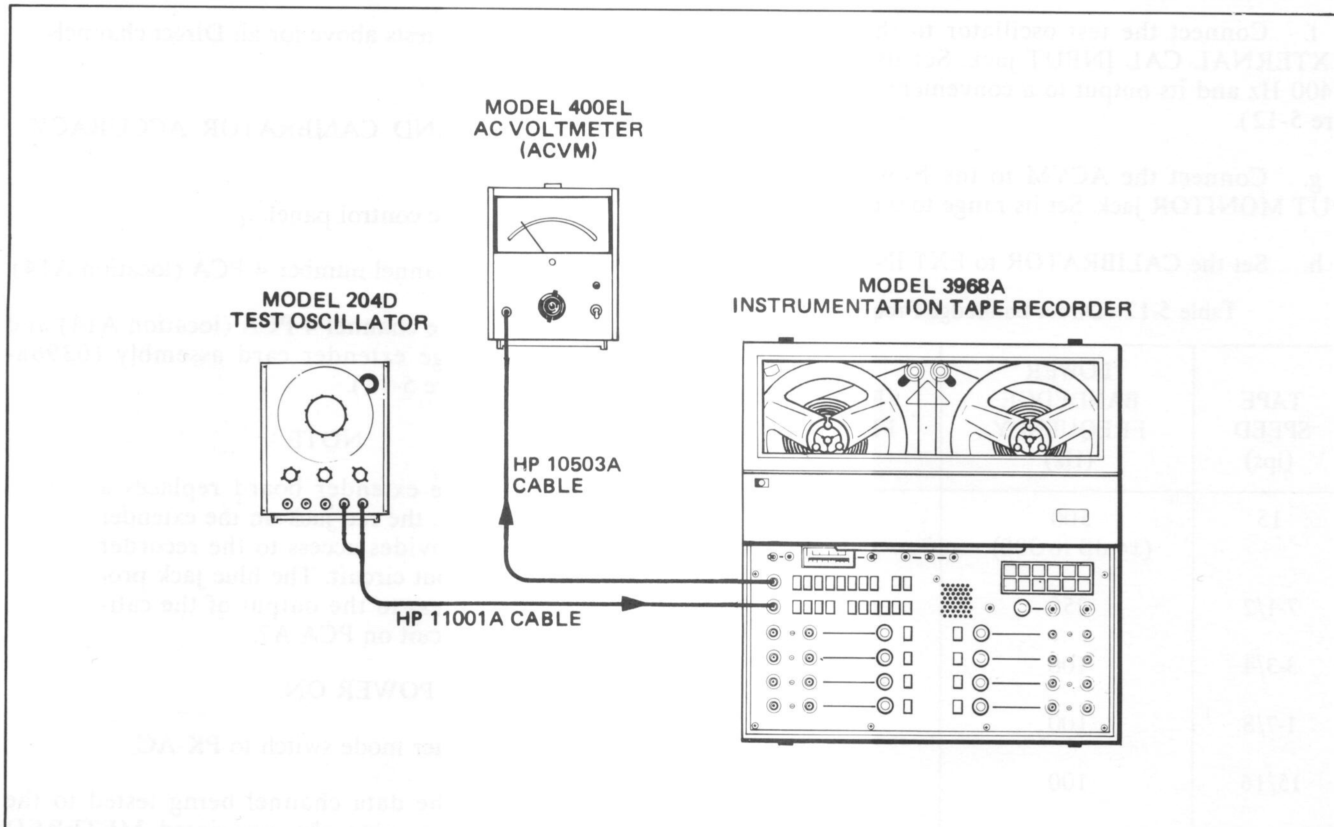


Figure 5-11. Direct Frequency Response Test Setup

level from the lower band edge to the upper band edge frequency. These frequencies are listed in Table 5-12.

p. Repeat these tests for all Direct channels.

5-61. DIRECT SIGNAL-TO-NOISE RATIO (SNR) TEST.

5-62. Direct signal-to-noise ratio is a measure of record/reproduce system noise. It includes noise generated by the recorder and by the tape. With a full scale record input (0 dB on the monitor meter), the reproduce output at 1/10 of the upper band edge frequency is used as a reference level. Broadband noise is measured without added filters. The direct SNR ratio test is conducted as follows:

a. Load the degaussed tape onto the machine.

b. Switch the POWER ON.

c. Set the meter mode switch to PK-AC.

d. Set the MONITOR selector for INPUT.

e. Connect the data channel being tested to the front panel meter using the associated METERED CHANNEL SELECTOR pushbutton.

f. Connect the test oscillator to the front panel EXTERNAL CAL INPUT jack. Set its frequency to 6400 Hz and its output to a convenient level (see Figure 5-12).

g. Connect the ACVM to the front panel OUTPUT MONITOR jack. Set its range to 0 dB (1V).

h. Set the CALIBRATOR to EXT INPUT.

Table 5-12. Direct Bandedge Frequencies

TAPE SPEED (ips)	LOWER BANDEDGE FREQUENCY (Hz)	UPPER BANDEDGE FREQUENCY (kHz)
15	500 (±4 dB to 300)	64
7-1/2	250	32
3-3/4	100	16
1-7/8	100	8
15/16	100	4
15/32	100	2

i. Set the data PCA OPERATE/CALIBRATE switch to CALIBRATE.

j. Select 15 ips (38.1 cm/s).

k. Adjust the PCA INPUT LEVEL control to obtain 0 dB on the front panel meter.

l. Press the RECORD and forward pushbuttons.

m. Adjust the PCA OUTPUT LEVEL control to obtain 0 dB on the ACVM.

n. Set the PCA OPERATE/CALIBRATE switch to OPERATE.

o. Set the ACVM to the -30 dB (30 mV) range.

p. Observe the minus dB reading of the noise. This minus dB reading is the positive SNR and must not be less than (a more positive meter reading) the value listed in Table 5-6.

NOTE

For each of the remaining speeds, reestablish the output reference level of 0 dB at 1/10 of the upper band edge frequency (see Table 5-12). Measure the noise as above and determine that the SNR is not less than the corresponding value listed in Table 5-6.

q. Repeat the tests above for all Direct channels.

5-63. METER AND CALIBRATOR ACCURACY TEST.

a. Remove the control panel.

b. Remove channel number 4 PCA (location A14).

c. Remove the channel 4 PCA (location A14) and replace with large extender card assembly (03968-60965) (see Figure 5-13).

NOTE

When the extender board replaces a data PCA, the red jack on the extender board provides access to the recorder meter input circuit. The blue jack provides access to the output of the calibrator circuit on PCA A7.

d. Switch the POWER ON.

e. Set the meter mode switch to PK-AC.

f. Connect the data channel being tested to the front panel meter using the associated METERED CHANNEL SELECTOR pushbutton.

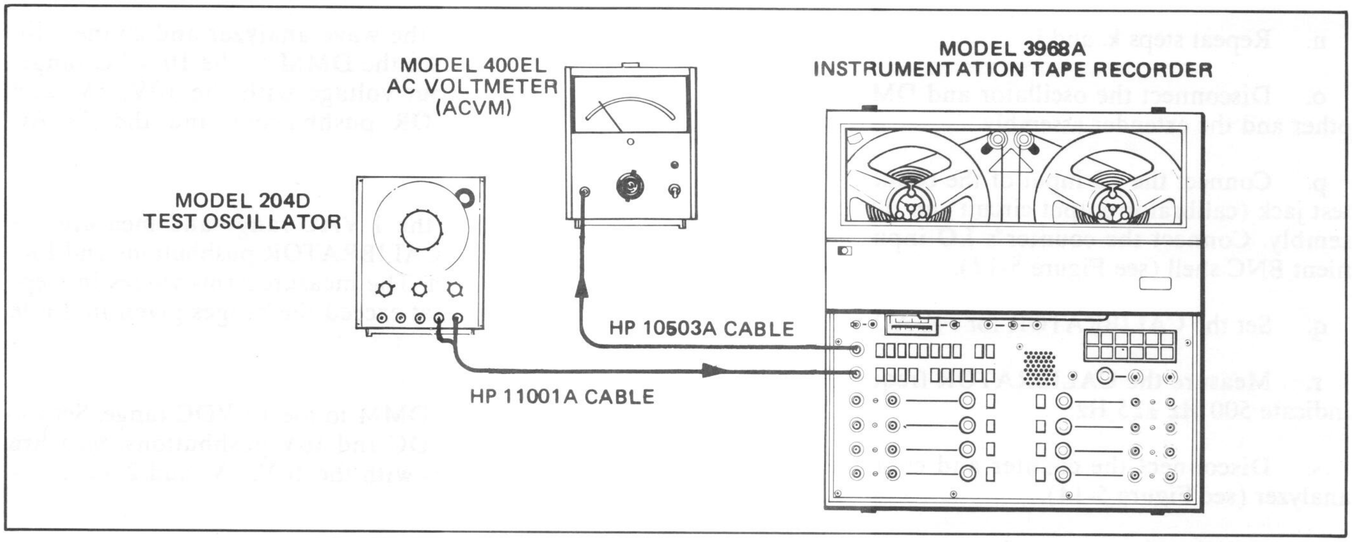


Figure 5-12. Direct Signal-To-Noise Test Setup

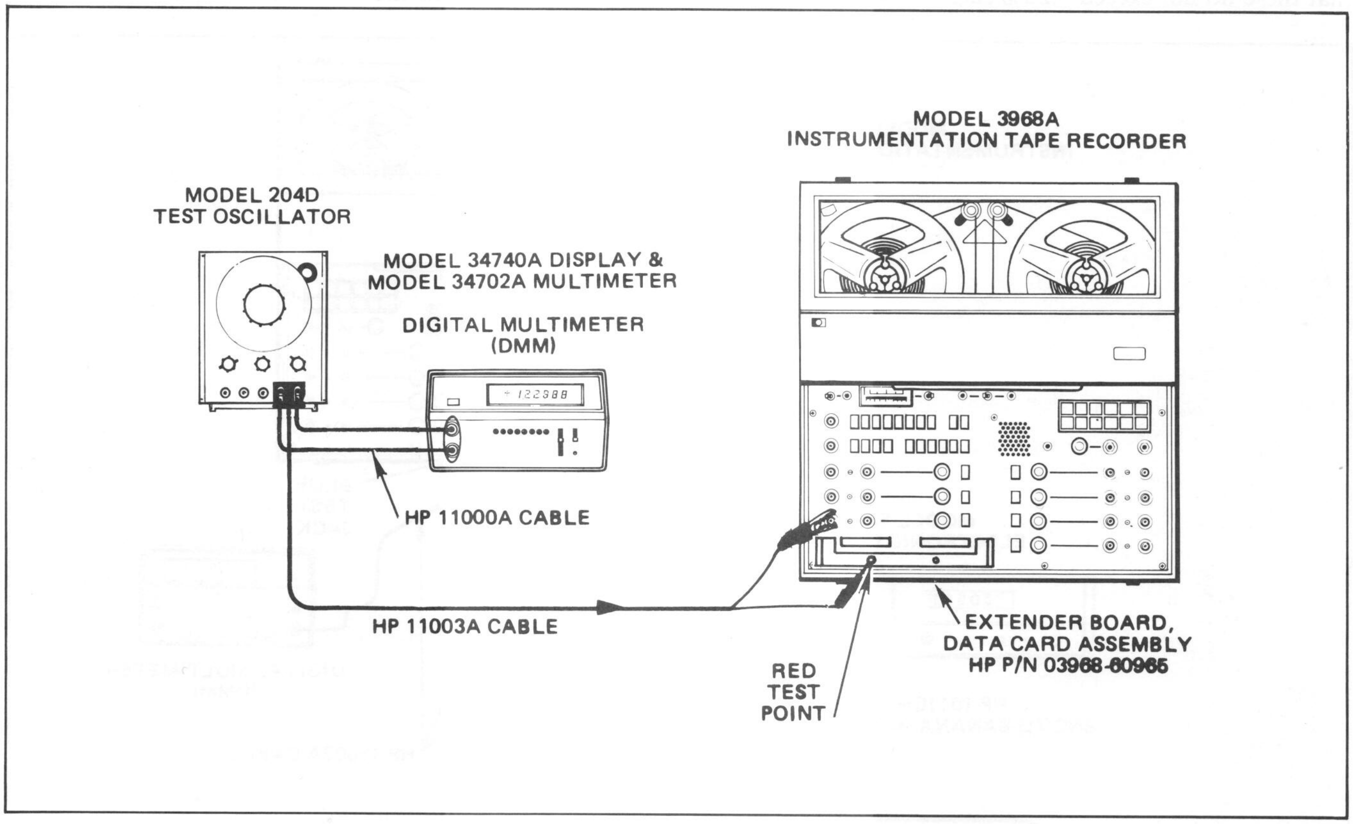


Figure 5-13. Meter Accuracy Test Setup

g. Set the MONITOR selector for INPUT.

h. Connect the test oscillator output to the DMM input and simultaneously to the red test jack (meter input circuit) on the extender assembly. Connect the oscillator LO output to a convenient BNC shell (see Figure 5-13).

i. Set the DMM to the 1V AC range.

j. Set the test oscillator to 500 Hz.

k. Adjust the oscillator output to obtain a reading of 1.768V ±0.010V on the DMM.

l. Observe the recorder meter reading. Should indicate 0 dB ±0.5 dB on the lower scale.

m. Change the oscillator frequency to 64 kHz.

n. Repeat steps k. and l.

o. Disconnect the oscillator and DMM from each other and the extender assembly.

p. Connect the HI input of the counter to the blue test jack (calibrator output circuit) on the extender assembly. Connect the counter's LO input to a convenient BNC shell (see Figure 5-14).

q. Set the CALIBRATOR for PK-AC and 10V.

r. Measure the CALIBRATOR frequency. Should indicate 500 Hz ±25 Hz.

s. Disconnect the counter and connect the wave analyzer (see Figure 5-14).

t. Utilizing the wave analyzer, measure the second and third harmonic distortion components. Determine that these do not exceed 0.25% each.

u. Disconnect the wave analyzer and connect instead the DMM. Set the DMM to the 10 VAC range. Measure the output voltage with the 10V, 5V, and 2.5V CALIBRATOR pushbuttons and the PK-AC pushbutton set.

v. Change to the 1 VAC range and measure the 1.4V with the 1V CALIBRATOR pushbuttons and PK-AC pushbutton set. The measured rms values in steps u. and v. should not exceed the ranges given in Table 5-13.

w. Change the DMM to the 10 VDC range. Set the CALIBRATOR +DC and 10V pushbuttons. Measure the output voltages with the 10V, 5V, and 2.5V pushbuttons set.

x. Change to the 1 VDC range and measure the output voltage with the 1.4V and 1V pushbuttons set.

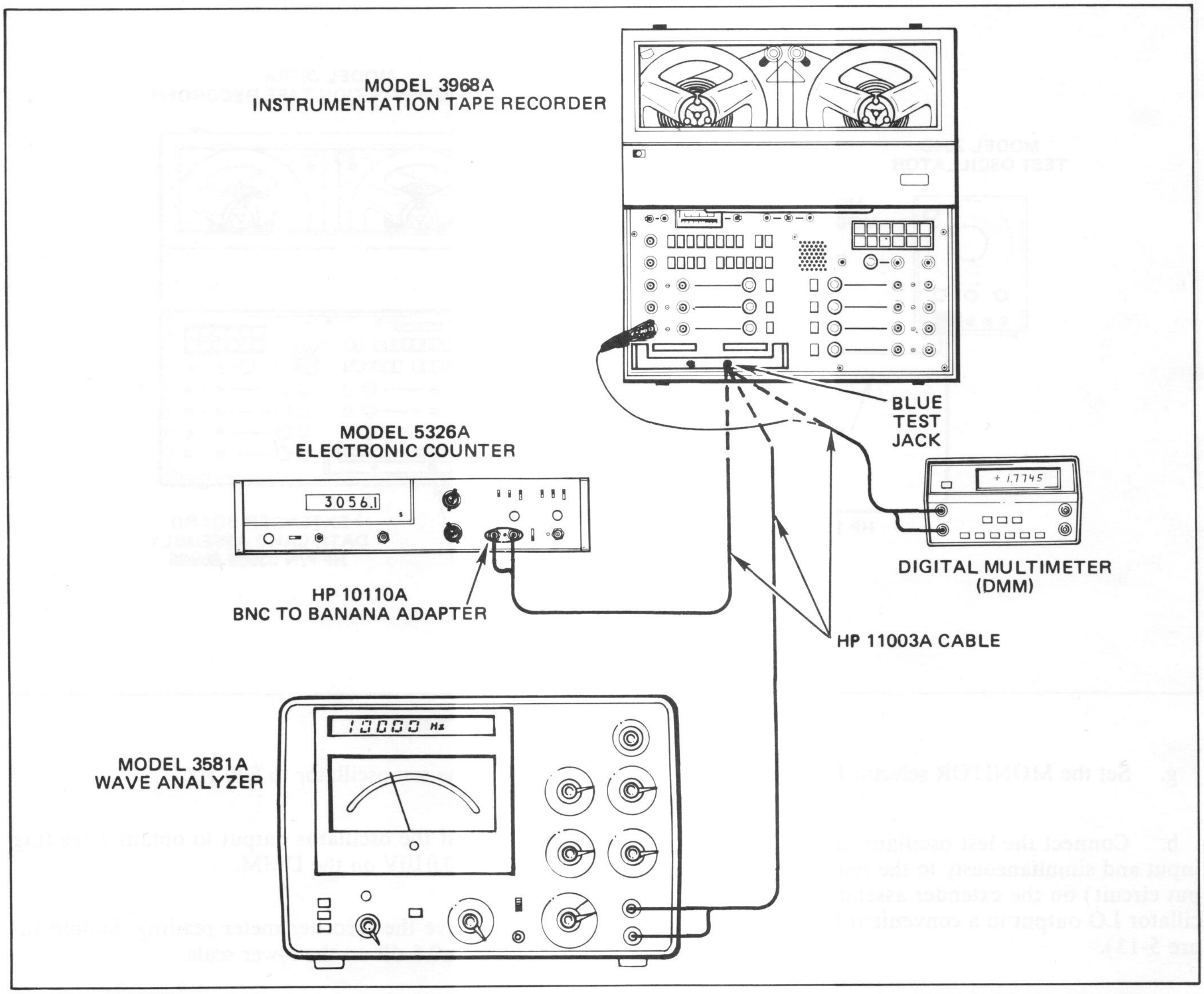


Figure 5-14. Calibrator Accuracy Test Setup

The measured DC values in steps w. and x. should not exceed the ranges given in Table 5-14.

y. Repeat steps w. and x. with the CALIBRATOR set for -DC.

5-64. CIRCUIT BOARD ADJUSTMENTS.

5-65. The following series of tests and adjustments are those recommended as part of a periodic calibration program or where tests in the preceding section fail to produce acceptable results. If there is evidence of an actual failure, then make necessary repairs before proceeding with these adjustments.

Table 5-13. Calibrator AC Voltages

VOLTAGE SELECTION (PK-AC)	MEASURED VOLTAGE IN RMS	
	MINIMUM	MAXIMUM
1 V	.693 V	.721 V
1.4 V	.980 V	1.020 V
2.5 V	1.732 V	1.803 V
5 V	3.465 V	3.606 V
10 V	6.930 V	7.212 V

Table 5-14. Calibrator DC Voltages

VOLTAGE SELECTION	MINIMUM ACCEPTABLE VOLTAGE	MAXIMUM ACCEPTABLE VOLTAGE
1 V	.980 V	1.020 V
1.4 V	1.386 V	1.442 V
2.5 V	2.450 V	2.550 V
5 V	4.900 V	5.100 V
10 V	9.800 V	10.200 V

5-66. PRELIMINARY REQUIREMENTS.

NOTE

Remove the top, side and front control panel to perform the following calibration procedures.

5-67. Make the following control settings on the rear panel:

a. Set the FLUTTER COMP switch to OFF.

b. Set the Servo Reference Selector switch (to the right of the three BNC's) to INTERNAL (lower position).

c. Set the power switch to AC.

d. Set the AC VOLTAGE SELECTOR switch to match the source.

e. Install the line cord.

5-68. Make the following control settings on the front panel:

a. Set the POWER switch to OFF.

b. Set the meter mode switch to DC.

c. Set the SERVO switch to TACH.

5-69. REGULATED VOLTAGE ADJUSTMENT (PCA A3).

a. Place the recorder in a horizontal position. Open and latch the transport.

b. Remove the Meter Amplifier PCA A3. Install it's extender board, 03968-60960, into the machine. Plug the meter amplifier into the extender (see Figure 5-15).

c. Plug the line cord into the mains, set the POWER switch to ON. Allow five minutes or more for warm-up.

d. Use the digital multimeter (DMM) set on 10 VDC range to measure the +10.5 regulated voltage. Connect the HI input of the DMM to the test point on the Interconnect PCA (near the Speed Control PCA) labeled +10. Connect the LO input of the DMM to the test point labeled COMMON in the center area.

e. Measure the value of the +10.5V supply. Should not exceed +10.495V to +10.505V. Adjust the trimmer labeled +10.5 ADJ on Meter Amplifier PCA A3 to achieve the correct reading.

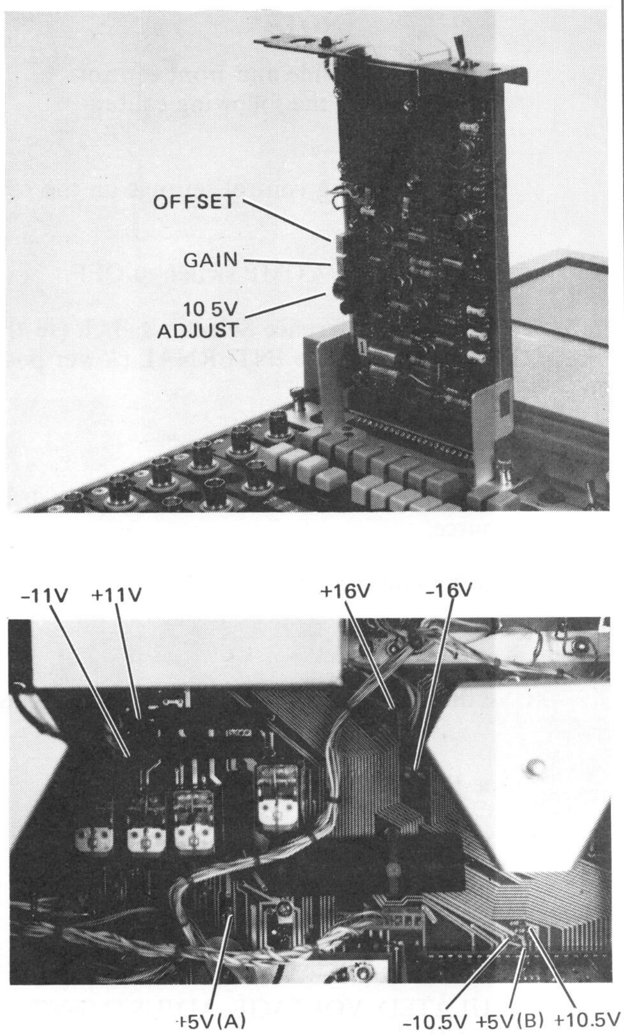


Figure 5-15. Regulated Voltage Test Points and Adjustments

f. Connect the HI input of the DMM to the test point labeled -10. Verify that the voltage is within the range of -10.470V to -10.530V.

g. Measure the +5A and +5B voltages at their respective test points on the Interconnect PCA (see Figure 5-15). Verify that each is within the range of +5.06V to +5.18V.

NOTE

The meter amplifier PCA may be left on its extender card for later calibration of the meter amplifier.

5-70. CALIBRATOR ADJUSTMENT (PCA A7).

5-71. Access to the calibrator output is obtained by switching the POWER OFF and removing one data card and installing in its place the large extender (part no. 03968-60965) as shown in Figure 5-13. The blue test jack is connected to the bus line distributed to all of the data PCA's. Connect the HI input of the electronic counter to this blue jack and the LO to the COMMON test point on the Interconnect PCA A24 or to the shell of an INPUT jack on a data PCA. Calibrator adjustments are as follows:

a. Connect the counter to the calibrator output as defined in paragraph 5-71 and apply power to the recorder. Set the CALIBRATOR for PK-AC and 10V.

b. Adjust the trimmer labeled FREQ on Calibrate/Servo PCA A7 (see Figure 5-16) for a 500 ±5 Hz indication on the counter.

c. Refer to paragraph 5-63, step s. through y. to check the AC, +DC and -DC outputs from the calibrator circuit.

5-72. METER ADJUSTMENTS (PCA A3).

NOTE

The calibrating adjustments listed in paragraph 5-70 should be completed before making the meter adjustments listed herein.

a. Turn the recorder power OFF.

b. Remove Meter Amplifier PCA A3 (see Figure 5-15).

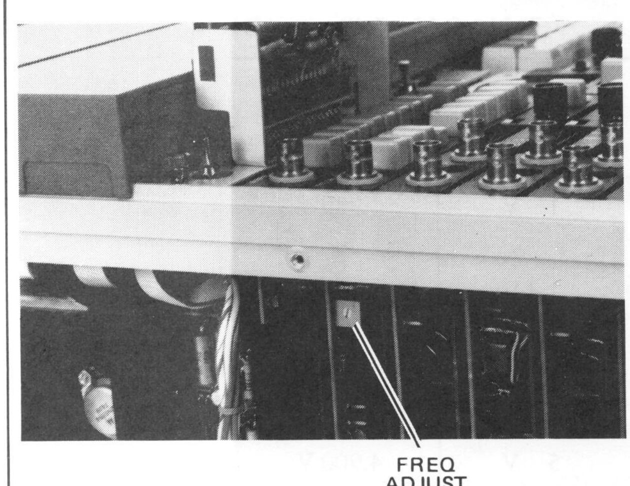


Figure 5-16. Calibrator Circuit Frequency Adjustment

NOTE

Meter calibration can most accurately be accomplished with the recorder positioned as it will be used most frequently. For example, if the recorder is to be rack mounted, calibrate with the tape transport in the vertical position.

c. Using the meter adjustment screw (located at bottom of meter between the terminals), mechanically adjust the meter. The pointer should be aligned to the extreme left mark on the lower scale ± one point width.

d. Reinstall Meter Amplifier PCA A3 on its extender board (Part No. 03968-60960).

e. Remove one data PCA and install extender board 03968-60965 in its place (see Figure 5-13).

NOTE

The extender board must **NOT** have a data PCA installed in it to proceed with meter calibration. The data PCA on the extender board will load the calibration voltage and make calibration impossible.

f. Connect a lead from the blue to red test jacks on extender board 03968-60965. This function connects the calibrator output to the meter amplifier input.

g. Set the recorder POWER switch ON.

h. Set the recorder meter mode switch to PK-AC.

i. Set the CALIBRATOR pushbuttons for PK-AC, 2.5V.

j. Set the MONITOR selector for INPUT.

k. Connect the data channel selected in step e. to the meter using the associated METERED CHANNEL SELECTOR pushbutton.

l. Adjust the GAIN trimmer on Meter Amplifier PCA A3 (see Figure 5-15) for a reading of 0 dB on the lower meter scale.

m. Set the recorder meter mode switch to DC.

n. Set the CALIBRATOR pushbuttons for +DC, 0V.

o. Adjust the OFFSET trimmer on Meter Amplifier PCA A3 (see Figure 5-15) for a reading of "O" on the upper meter scale.

p. Switch the recorder POWER switch OFF.

q. Remove the Meter Amplifier PCA from the extender board and reinstall the PCA in the recorder.

r. Remove data extender board and reinstall data PCA into appropriate location.

5-73. BIAS OSCILLATOR ADJUSTMENT (PCA A4).

a. Load the recorder with a degaussed reel of tape, full reel on the left.

b. Remove recorder control panel.

c. Connect the oscilloscope, using a X10 calibrated probe, to the B and NB square pins on the Interconnect board at the bottom front of the instrument (see Detail A, Figure 5-17).

NOTE

Connect the high oscilloscope lead to the "B" pin and the oscilloscope common lead to the "NB" pin.

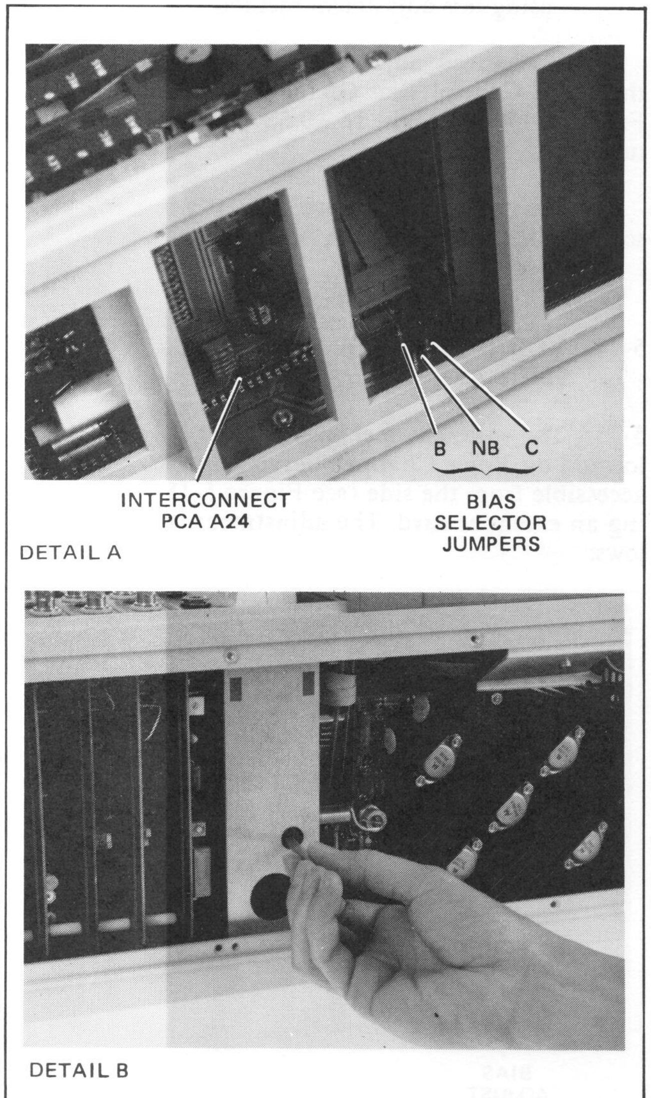


Figure 5-17. Bias Level Test Setup and Adjustment

d. Extend Speed Control/Bias Oscillator PCA A4 using extender board 03968-60960 or perform adjustment using procedure in step h.

e. Set recorder POWER to ON.

f. Actuate RECORD-forward at 3-3/4 ips (38.1 cm/s).

g. Observe the bias signal amplitude on the oscilloscope.

CAUTION

An alternate method of adjusting resistor R14 without extending PCA A4 is available. This method requires turning the resistor through a hole in the support bracket on the right side of the recorder. To prevent shorts, an insulated tool should be employed when using this adjustment method.

h. If required, adjust bias control resistor R14 on the Speed Control/Bias Oscillator PCA (see Detail B, Figure 5-17) to obtain 16 ±0.5V peak-to-peak amplitude.

i. Stop the tape, remove power, and the oscilloscope probes. Reinstall PCA A4 in the recorder.

5-74. VOICE CHANNEL BIAS ADJUSTMENT (PCA A8).

5-75. The voice channel bias trimmer is labeled BIAS located on Voice Channel/Servo Loop PCA A8. It is accessible from the side (see Figure 5-18) without using an extender card. The adjustment is made as follows:

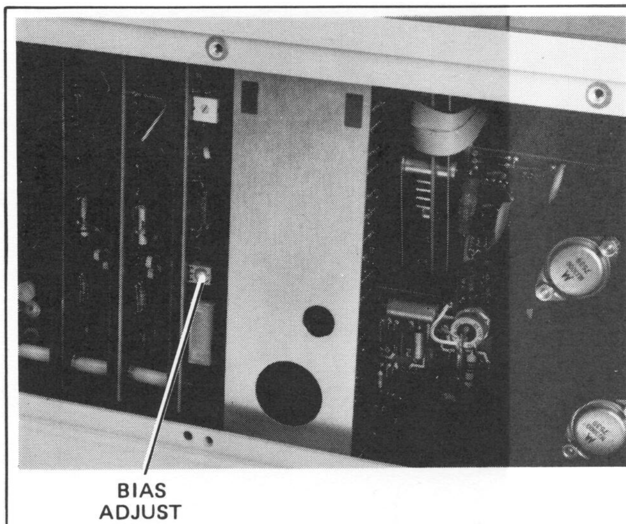


Figure 5-18. Voice Channel Bias Adjustment

a. Plug the microphone into its jack. Be sure the plug is completely seated.

b. Select 3-3/4 ips (9.52 cm/s). Press the RECORD and forward pushbuttons.

c. Operate the push-to-talk button on the microphone and say a few words.

d. Stop the tape.

e. Play in the reverse direction until past the beginning of the speech.

f. Play forward and listen to the quality. The speech should sound clear, intelligible, with little noise.

g. If the quality is satisfactory, repeat the tests at all speeds. Note that the quality and general level are noticeably poorer at 15/32 ips (1.19 cm/s).

NOTE

If the quality is not satisfactory, return the recorder to 3-3/4 ips (9.52 cm/s) and proceed with step l.

h. Turn the BIAS trimmer fully counterclockwise noting the angle of the adjustment slot.

i. Reset the reel revolution counter.

j. Press the forward (>) and RECORD pushbuttons.

k. Operate the push-to-talk button on the microphone.

l. While recording, make a series of voice annotations and accompanying systematic BIAS trimmer adjustments so that voice is recorded at several angles of the BIAS trimmer. An example of a recording might be: "The BIAS trimmer is at 4 o'clock, 6 o'clock, 7 o'clock, 8 o'clock, 9 o'clock, 10 o'clock, 11 o'clock, 12 o'clock, 1 o'clock."

m. Rewind using fast reverse mode to the 0000 Reel Revolution Counter coding point on the tape.

n. Press the forward (>) pushbutton.

o. Adjust the VOLUME control for normal listening level and listen closely to the test recording.

p. Set the BIAS trimmer to the setting noted in step l. that provided the best quality voice.

q. When the quality at 3-3/4 ips (9.52 cm/s) is satisfactory, check the remaining speeds.

r. This completes the voice channel bias adjustment.

5-76. SERVO PHASE BALANCE (SYM) ADJUSTMENT (PCA A8).

a. Switch the POWER OFF.

b. Remove Voice Channel/Servo Loop PCA A8 and re-install it on the large extender card (03968-60965) (see Figure 5-19).

c. Connect the oscilloscope HI input to TP7, and the LO input to TP12 (see Figure 5-19).

NOTE

If an oscilloscope is not available, an HP 427A Multimeter, or equivalent, can be used for this adjustment. Connect the meter to the test points listed in step c. and adjust the SYM resistor for approximately 1.9 VDC (50% duty cycle).

d. Switch the POWER ON and select 15/16 ips (2.38 cm/s).

e. Press the forward pushbutton and observe the square wave on the oscilloscope.

f. Adjust the SYM trimmer (see Figure 5-19) for a 50% average duty cycle.

g. Press the reverse pushbutton and again observe the duty cycle which generally differs from the forward duty cycle.

h. Adjust the SYM trimmer while switching between forward and reverse directions until the duty cycles obtained are approximately symmetrical about 50%.

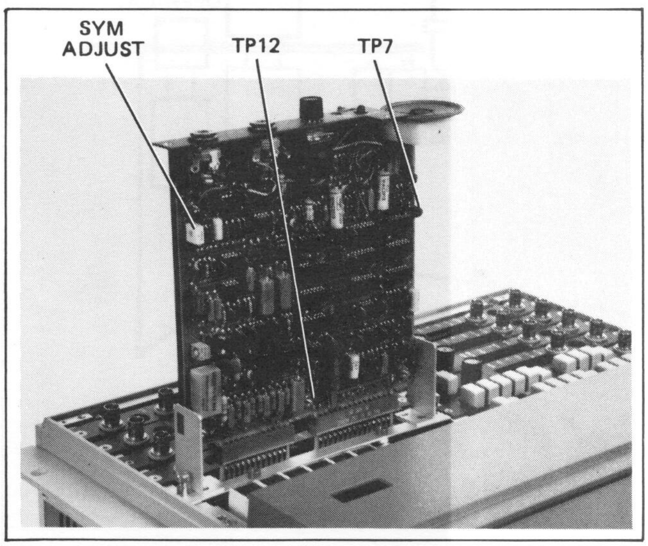


Figure 5-19. Servo Phase Balance (SYM) Adjustment

i. Switch the POWER OFF and reinstall the Voice Channel/Servo Loop PCA into the recorder.

5-77. 3968 FM DATA PCA ADJUSTMENT (NON-BIAS OPERATION).

a. Set the recorder POWER switch OFF and remove front panel.

b. Remove the FM data PCA to be adjusted and check that board jumpers are connected as follows (see Figure 3-5):

Unipolar Input Selector between pins C and O

Unipolar Output Selector between pins C and O

Tape Servo Selector between C and O

Input Dubbing between C and N

Output Dubbing between C and N

Amplitude/Phase between C and A

Bias between C and NB

Equalization Selector between pins C and 1 or C and 2 as required.

NOTE

The equalization selector is positioned between pins C and 1 for non-bias operation in a Model 3964A. All other cases such as 3964A bias and 3968A bias and non-bias operation select pins C and 2 positions.

c. Set recorder POWER switch ON, and select the STOP mode and 3-3/4 ips SPEED.

d. Set the CALIBRATOR for -DC and 0V.

e. Set the PCA OPERATE-CALIBRATE pushbutton to CALIBRATE and allow a few minutes for warmup.

f. Connect the counter to PCA connector J1 on the front panel. The shell of the INPUT or OUTPUT connector can be used as a ground (see Figure 5-20).

g. Adjust the MOD potentiometer on the PCA front panel to obtain a 6750 Hz ±3 Hz reading on the counter.

h. Retain the counter connection at J1 and connect a digital multimeter to connector J2 on the front panel.

i. Adjust the DMOD potentiometer on the PCA front panel to obtain a reading of 0V ±0.002V on the DMM.

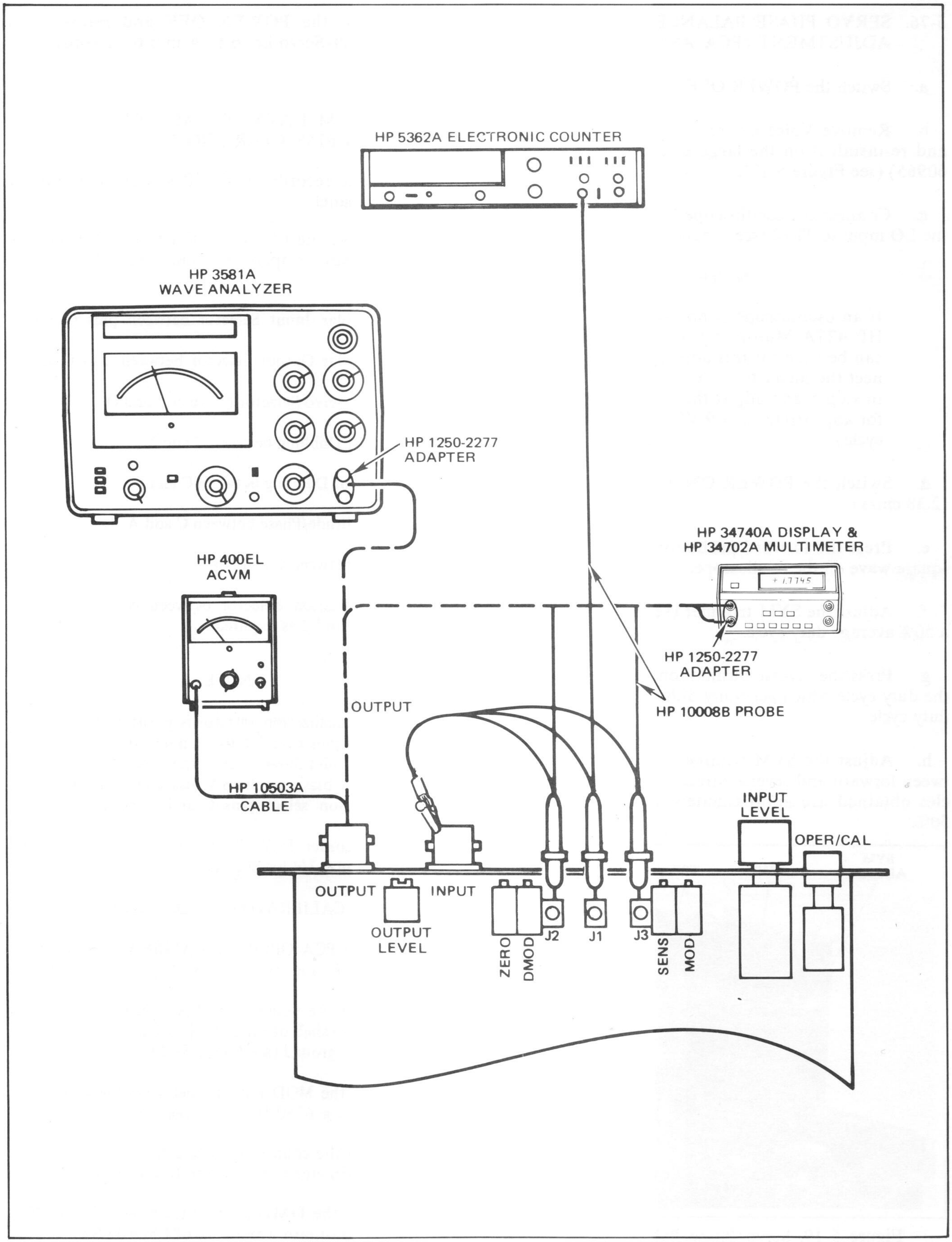


Figure 5-20. FM Data PCA Adjustments

j. Disconnect the DMM at J2 and reconnect to connector J3 on the PCA front panel.

k. Set the CALIBRATOR for -DC and 1V.

l. Adjust the PCA INPUT LEVEL control to obtain a -2.5V ±0.01V reading on the DMM.

m. Adjust the SENS potentiometer on the PCA front panel to obtain a 4050 Hz ±3 Hz reading on the counter connected at J1.

n. Set CALIBRATOR to 0V and turn PCA OUTPUT LEVEL control fully clockwise.

o. Disconnect the DMM at connector J3 and connect to the PCA OUTPUT BNC.

p. Adjust ZERO potentiometer on PCA front panel for a DMM reading of 0 ±0.003V.

q. Set the CALIBRATOR for 1V.

r. Adjust the PCA OUTPUT LEVEL control for a -2.5 ±0.05V reading on the DMM.

s. Set the CALIBRATOR for 0V and disconnect all test equipment.

5-78. 3964 FM DATA PCA ADJUSTMENT (NON-BIAS OPERATION).

a. Perform steps a. through p. in paragraph 5-77 and proceed with the following procedures. Check position of Equalization Selector jumper (see NOTE in step b.).

b. Select 15 ips speed on the recorder.

c. Set the meter mode switch to PK-AC.

d. Set the MONITOR pushbutton for INPUT.

e. Set the METERED CHANNEL SELECTOR for the channel being tested.

f. Connect a test oscillator to the EXTERNAL CAL INPUT BNC, and set for an output of 2500 Hz with a convenient output signal level.

g. Connect a wave analyzer to the PCA OUTPUT BNC.

h. Set the CALIBRATOR for EXT INPUT.

i. Set the PCA OPERATE/CALIBRATE switch for CALIBRATE.

j. Adjust the PCA INPUT LEVEL for a 0 dB reading on the recorder meter.

k. Adjust the wave analyzer for the desired reference level at the fundamental frequency for 15 ips (2500 Hz).

l. Tune the wave analyzer to the second harmonic (5000 Hz).

m. Set the recorder MODE for forward-RECORD.

n. Adjust the PCA EQ trimmer for a minimum reading on the wave analyzer.

NOTE

The EQ adjustment may be fully clockwise or counterclockwise.

o. Set the recorder MODE to STOP. Proceed to the adjustment of the next PCA or disconnect all test equipment.

5-79. 3968 FM DATA PCA ADJUSTMENT (BIAS OPERATION).

a. Perform steps a. through p. in paragraph 5-77.

b. Connect an AC voltmeter set to the 10 mV range to the PCA OUTPUT BNC.

c. Set the recorder to the forward-RECORD mode at 15 ips SPEED.

d. Adjust BIAS trimmer on PCA for a minimum indication on ACVM.

e. Disconnect all test equipment.

5-80. 3964 FM DATA PCA ADJUSTMENT (BIAS OPERATION).

a. Perform steps a. through p. in paragraph 5-77. Check position of Equalizer Selector jumper as stated in step b. Jumper should be connected between pins C and 2.

b. Perform steps b. through m. in paragraph 5-78.

c. Adjust BIAS trimmer on PCA front panel for a minimum reading on the wave analyzer.

d. Set the recorder MODE to STOP. Proceed to the adjustment of the next PCA or disconnect all test equipment for operation.

5-81. FM DATA PCA ADJUSTMENT (POSITIVE UNIPOLAR OPERATION).

NOTE

If the FM PCA is being operated with no bias, complete steps a. through q., paragraph 5-77 before starting the following procedure. If the PCA is being operated with bias, complete steps a. through q. of paragraph 5-75 and steps a. through d. of paragraph 5-79 before proceeding.

a. Connect Unipolar Input Selector jumper between pin C and the negative (-) pin for positive input signals (see Figure 3-5).

b. Connect Unipolar Output Selector jumper between pin C and the negative pin (-) if a similar unipolar reproduce output is desired.

c. Install the PCA and set the recorder POWER switch ON.

d. Set the recorder MODE to STOP and select 3-3/4 ips SPEED.

e. Set the CALIBRATOR for -DC and 0V.

f. Set the PCA OPERATE-CALIBRATE pushbutton for CALIBRATE.

g. Connect a counter to connector J1 on the PCA front panel.

h. Adjust the PCA MOD trimmer for a 4050 ±3 Hz counter reading.

i. Connect a DMM to the PCA OUTPUT BNC if an adjustment of unipolar output is necessary.

j. Adjust the PCA ZERO trimmer to obtain a 0 ±0.005V reading on the DMM.

k. Disconnect all test equipment.

5-82. FM DATA PCA ADJUSTMENT (NEGATIVE UNIPOLAR OPERATION).

NOTE

If the FM PCA is being operated with no bias, complete steps a. through q., paragraph 5-77. If the PCA is being operated with bias, complete steps a. through q., paragraph 5-75 and steps a. through d. paragraph 5-79.

a. Connect Unipolar Input Selector jumper between pin C and the positive (+) pin for negative input signals (see Figure 3-5).

b. Connect Unipolar Output Selector jumper between pin C and the positive (+) pin if a similar unipolar reproduce output is desired.

c. Install the PCA and set the recorder POWER switch ON.

d. Set the recorder MODE for STOP and SPEED at 3-3/4 ips.

e. Set the CALIBRATOR for -DC and 0V.

f. Set the PCA OPERATE-CALIBRATE pushbutton for CALIBRATE. Allow a few minutes warmup.

g. Connect the counter to PCA connector J1. Use any convenient ground.

h. Adjust the PCA MOD trimmer for a counter reading of 9450 ±3 Hz.

i. Connect a DMM to the PCA OUTPUT BNC if an adjustment of unipolar output is necessary.

j. Adjust the PCA ZERO trimmer for a 0 ±0.005V on the DMM.

k. Disconnect all test equipment for operation.

5-83. DIRECT DATA PCA ADJUSTMENTS.

a. Remove the Direct PCA to be adjusted.

NOTE

The equalization jumpers are connected between the unmarked pin and pin X when using Type 3M888 tape or equivalent. Jumper positions Y and Z are used for audio tapes. After changing jumper positions the following adjustments should be performed.

b. Verify that its equalizer selector jumpers are properly positioned for the type of tape being used. Both jumpers should be set to the same letter code (see Figure 3-8).

c. Reinstall the PCA in the instrument.

d. Connect the test oscillator to the INPUT BNC (see Figure 5-21).

e. Set oscillator to 16 kHz and a convenient level constant throughout the calibration.

f. Set the OPERATE/CALIBRATE switch to OPERATE.

g. Set the METERED CHANNEL SELECTOR for the channel being calibrated.

h. Set the MONITOR to INPUT.

i. Set the meter mode to PK-AC.

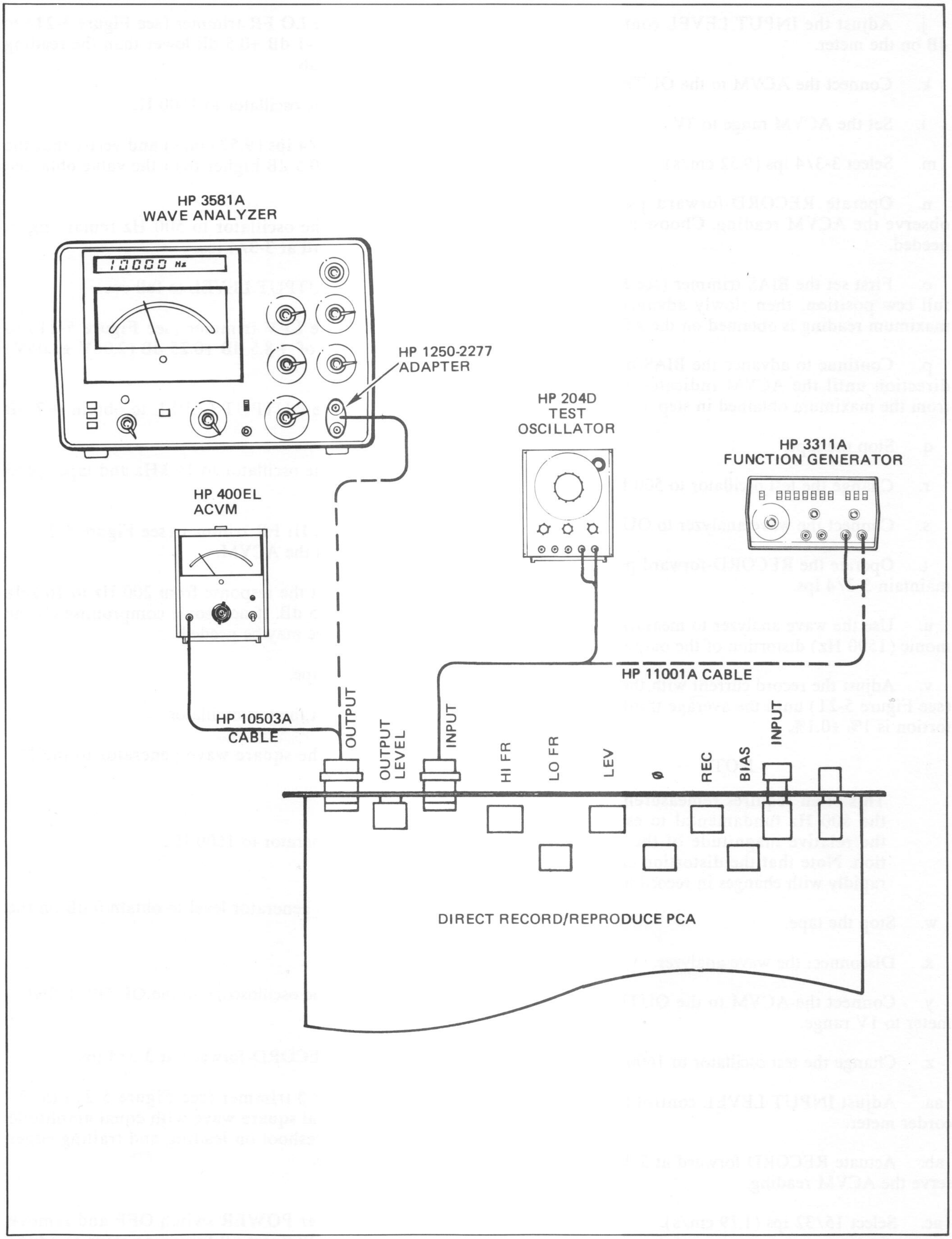


Figure 5-21. Direct Record/Reproduce Adjustment

j. Adjust the INPUT LEVEL control to obtain 0 dB on the meter.

k. Connect the ACVM to the OUTPUT BNC.

l. Set the ACVM range to 3V.

m. Select 3-3/4 ips (9.52 cm/s).

n. Operate RECORD-forward pushbuttons and observe the ACVM reading. Choose a lower range if needed.

o. First set the BIAS trimmer (see Figure 5-21) to full ccw position, then slowly advance it cw until a maximum reading is obtained on the ACVM.

p. Continue to advance the BIAS trimmer in a cw direction until the ACVM indicates an output 3 dB from the maximum obtained in step o.

q. Stop the tape.

r. Change the test oscillator to 500 Hz.

s. Connect the wave analyzer to OUTPUT BNC.

t. Operate the RECORD-forward pushbuttons and maintain 3-3/4 ips.

u. Use the wave analyzer to measure the third harmonic (1500 Hz) distortion of the output signal.

v. Adjust the record current with the REC trimmer (see Figure 5-21) until the average third-harmonic distortion is 1% ±0.1%.

NOTE

This often requires remeasurement of the 500 Hz fundamental to establish the relative magnitude of the distortion. Note that the distortion changes rapidly with changes in record level.

w. Stop the tape.

x. Disconnect the wave analyzer.

y. Connect the ACVM to the OUTPUT BNC. Set meter to 1V range.

z. Change the test oscillator to 1600 Hz.

aa. Adjust INPUT LEVEL control for 0 dB on recorder meter.

ab. Actuate RECORD-forward at 3-3/4 ips and observe the ACVM reading.

ac. Select 15/32 ips (1.19 cm/s).

ad. Change the oscillator to 200 Hz.

ae. Adjust the LO FR trimmer (see Figure 5-21) to obtain a reading -1 dB ±0.5 dB lower than the reading obtained in step ab.

af. Change the oscillator to 1600 Hz.

ag. Select 3-3/4 ips (9.52 cm/s) and verify that the output is 1 dB ±0.5 dB higher than the value obtained in step ae.

ah. Change the oscillator to 500 Hz remaining in RECORD-forward at 3-3/4 ips.

ai. Set the OUTPUT LEVEL to full cw.

aj. Adjust the LEV trimmer (see Figure 5-21) to obtain a reading of +8.5 dB ±0.25 dB (2.06V ±0.06V) on the ACVM.

ak. Adjust the OUTPUT LEVEL to obtain +7 dB on the ACVM.

al. Change the oscillator to 16 kHz and tape speed to 3-3/4 ips.

am. Adjust the HI FR trimmer (see Figure 5-21) to obtain +7 dB on the ACVM.

an. Verify that the response from 200 Hz to 16 kHz is flat within ±1.5 dB. If not, some compromise on the adjustments above may be needed.

ao. Stop the tape.

ap. Disconnect the test oscillator.

aq. Connect the square wave generator to the INPUT BNC.

ar. Set the generator to 1600 Hz.

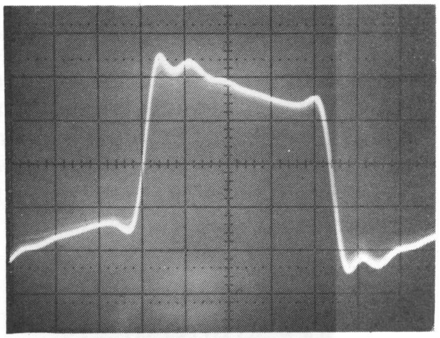
as. Adjust the generator level to obtain 0 dB on the recorder meter.

at. Connect the oscilloscope to the OUTPUT BNC.

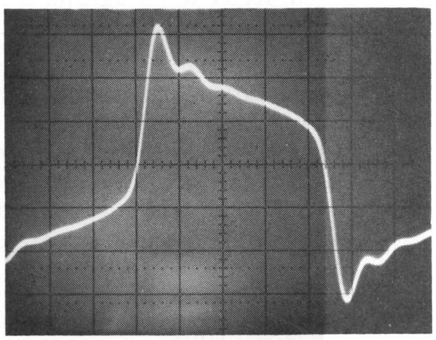
au. Actuate RECORD-forward at 3-3/4 ips.

av. Adjust the $\emptyset$ trimmer (see Figure 5-21) to obtain a symmetrical square wave with equal amplitude overshoot and preshoot on leading and trailing edges (see Figure 5-22).

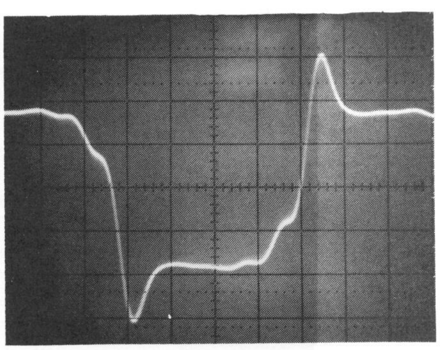
aw. Set recorder POWER switch OFF and remove test connections. Perform all foregoing steps to adjust Direct Data PCA's.



DETAIL A – PROPER ADJUSTMENT



DETAIL B – FULL COUNTERCLOCKWISE



DETAIL C – FULL CLOCKWISE

Figure 5-22. Phase (∅) Adjustment Waveforms

5-84. OVERLAP PCA ADJUSTMENTS (OPTION 070 ONLY).

a. Remove left-hand (viewed from front) side cover on recorder exposing Overlap PCA adjustments (see Figure 5-23).

b. Load tape, set recorder POWER switch ON, and move tape in Fast Forward mode until less than 1/8-inch thickness of tape remains on supply (left) reel.

c. Set recorder mode to STOP.

d. Connect oscilloscope to test point TP2 (see Figure 5-23).

e. Set overlap switch on the recorder transport assembly to RWD (rewind).

f. Set recorder to Forward mode and 3-3/4 ips speed.

g. Adjust GAIN control (see Figure 5-23) for 3V p-p square wave output on oscilloscope.

NOTE

Overlap recorders are normally adjusted with the TIME potentiometer (see Figure 5-23) fully counterclockwise. At this setting, the first recorder will go into rewind (fast reverse) at 20 ±10 seconds after the following recorder starts its Forward-RECORD operation. The TIME control is turned clockwise to increase time between the turn-on of the following recorder and a rewind or stop function in the first recorder.

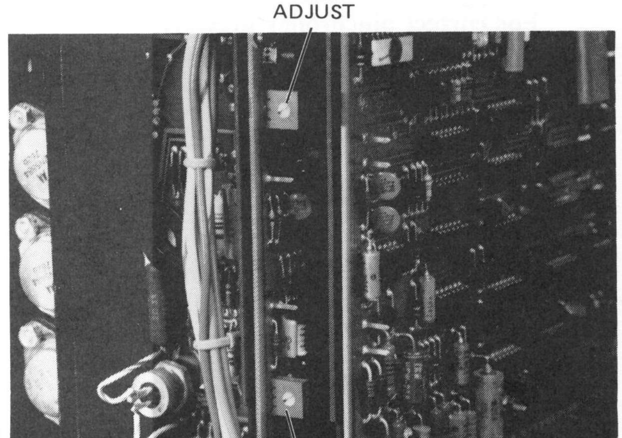


Figure 5-23. Overlap PCA Adjustment

5-85. MECHANICAL ADJUSTMENTS.

5-86. Mechanical parts requiring adjustment include the pinchroller solenoid, reel brake and end-of-tape (EOT) switches. Procedures are as follows.

5-87. PINCHROLLER SOLENOID ADJUSTMENT.

5-88. The following procedure describes how the pinchroller solenoid should be adjusted to assure correct pinchroller pressure when in play and RECORD modes; and to provide correct clearance of .030 to .038 inches (.76 to .97 mm) between the pinchroller and capstan under other conditions. If adjustment is required proceed as follows:

a. Remove reels and recording tape.

b. Remove the control panel.

c. Place the recorder flat on the bench with the transport facing up and the line cord installed.

d. Open and latch the transport. Two screws secure it on the right side.

e. Tape one of the damper arms down past the microswitch "click" point (see Detail A, Figure 5-24).

f. Apply power to the recorder. If STOP light does not light, check step e.

g. Push the Forward or REVERSE pushbutton.

h. Measure clearance between the pinchroller roll pin and bottom of slot in rocker arm (see Detail B, Figure 5-24).

NOTE

For correct pinchroller pressure there should be clearance of between .020 and .030 inches (.51 mm and .76 mm) between the roll pin and the bottom of the slot in the rocker arm that houses the pinchroller.

NOTE

If the roll pin clearance is incorrect; loosen the pinchroller roll pin clearance adjustment screws, slide solenoid in adjustment slots for correct clearance and tighten screws (see Detail D, Figure 5-24).

i. Recheck clearance and readjust as required.

j. Push STOP.

k. Measure the pinchroller to capstan clearance with a feeler gauge (see Detail C, Figure 5-24). If it is outside of the specified tolerance of .030 to .038 inches (.76 to .97 mm) adjustment is required.

NOTE

To adjust the pinchroller to capstan clearance loosen the locknut and turn adjustment screw until proper clearance is obtained (see Detail D, Figure 5-24). Retighten locknut and recheck clearance.

5-89. REEL BRAKE ADJUSTMENTS.

NOTE

Do not adjust the brakes until they have been cleaned. Cleaning may solve the problem. Refer to paragraph 5-13 for brake cleaning instructions.

5-90. The following procedure describes the adjustment of the brake linkage. When the brakes are properly adjusted, both reel brakes should grip and release simultaneously; and there should be proper clearance between the brakes and the reel hubs when the brake solenoid is energized. Procedures for adjusting the brake follows:

a. Remove the power cord.

b. Remove the control panel. Refer to paragraph 5-95.

c. Remove the reel cover. Refer to paragraph 5-105.

d. Place recorder on its top with the reels facing the front.

e. Open the transport so that the front surface is even with the work bench. Two screws on the left side secure the transport.

f. Install an empty reel on each side of the transport.

g. Attach a six-ounce (.17 kg) weight on the end of a 4-foot (1.2 meter) string and wind this string counterclockwise on the left reel.

h. Attach a similar six-ounce (.17 kg) weight to the end of another equal length string and wind clockwise on the right reel.

Figure 5-24. Pinchroller Adjustment

NOTE

The exact value of the weights is not of primary importance as long as they are approximately the weight specified; however the weights should be equally heavy to obtain correct results. The relaxed brakes should prevent the weights from falling.

i. Adjust the weights to equal heights.

NOTE

The brakes can manually be released by pushing in the brake solenoid plunger which is located at the lower left corner of the transport (see Detail A, Figure 5-25).

j. Manually release the brakes very slowly until both weights start falling. Hold the brakes in this position and observe the weights as they fall.

NOTE

The weights should drop at approximately the same speed to stop at the floor at about the same time. If the weights drop at unequal speed proceed with the following adjustments.

k. Turn the adjustment setscrew with a .050 inch Allen screwdriver either direction (see Detail B, Figure 5-25).

l. Rewind the string on the reels and repeat step j. and k. until the weights fall at the same speed.

m. Remove the string and weights from the reels.

n. Manually depress the brake solenoid plunger as far as possible while spinning the empty reels with your hand. The reels should turn freely in both directions and stop immediately when the solenoid is released.

o. If adjustment is required, loosen screw (see Detail C, Figure 5-25), move bracket in slot, retighten screw, and repeat n. until reels are free with solenoid plunger depressed and stop quickly when released.

5-91. END OF TAPE SWITCH ADJUSTMENT.

5-92. The end of tape switch adjustment is made as follows:

a. Remove the reels and tape from the transport.

b. Manually depress a tape roller toward the nearest reel hub to simulate tape tension.

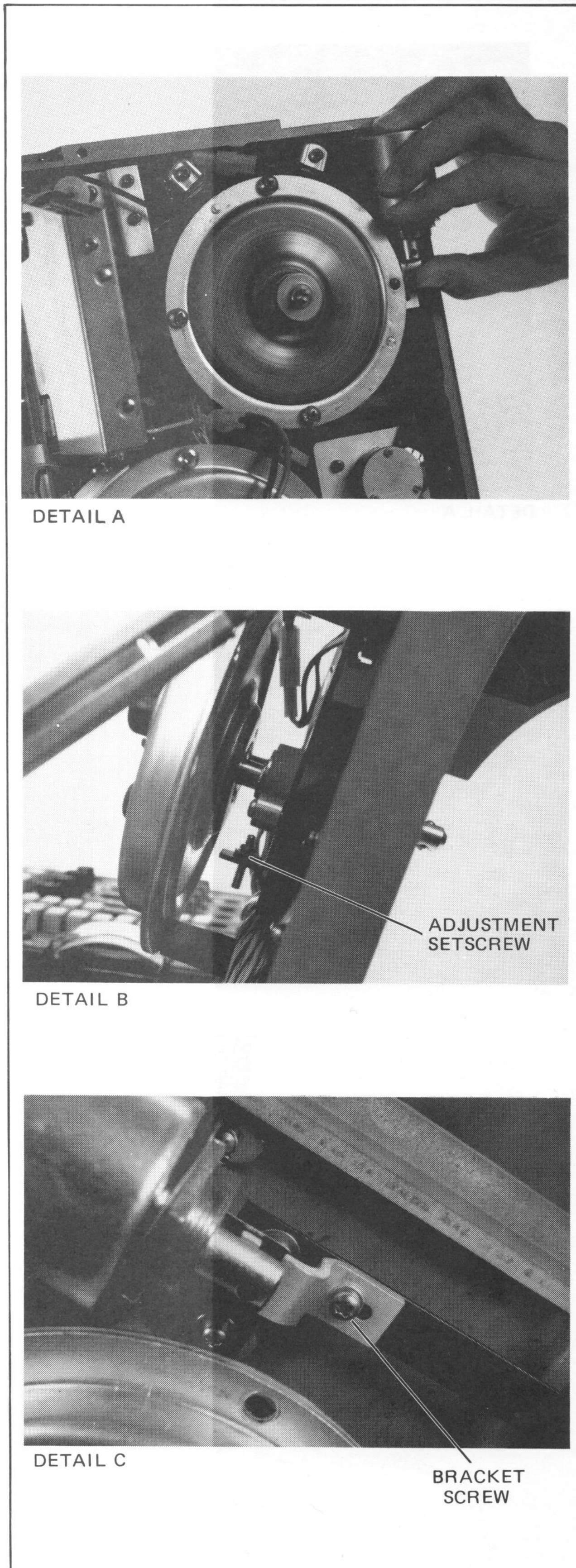


Figure 5-25. Brake Adjustment

c. Slowly return roller toward the relaxed position while noting the distance between when the audible "click" of the end-of-tape switch occurs and when the roller is in the UP position. There should be between .032 and .064-inches (.81 and 1.63 mm) difference between the two positions as measured with a scale.

d. If adjustment is necessary, remove the reels, tape, and power cord. Proceed with the following steps:

e. Remove the control panel.

f. Position recorder with transport facing upward.

g. Remove two screws which retain transport, open transport and latch.

h. Loosen the damper assembly mounting screws (see Figure 5-25).

i. Reposition damper assembly to obtain correct clearances as described in step c. If not possible, move to best position.

j. Tighten mounting screws and recheck clearances.

k. If correct clearances were not obtainable in step i., loosen the microswitch retaining screws of the switch nearest to the damper of the end of tape which needs adjustment (see Figure 5-26).

l. Move switch and retighten screws until the tolerance of step c. is satisfied.

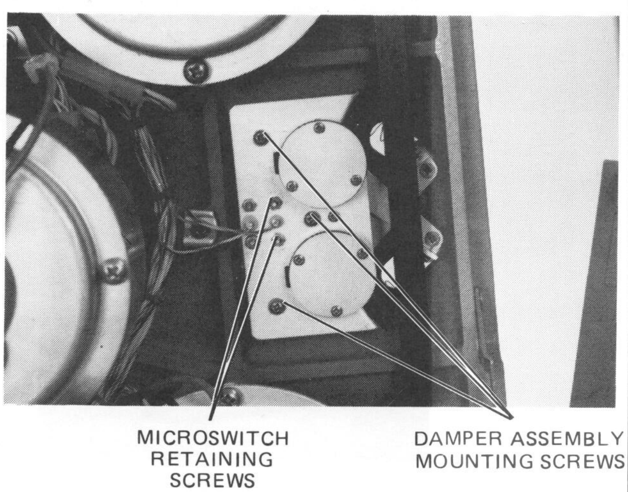


Figure 5-26. End-Of-Tape Switch Adjustment

5-93. REPAIR AND REPLACEMENT OF PARTS.

WARNING

Repair and replacement and parts should normally be accomplished with the line cord removed to minimize the possibility of electrical shock.

5-94. Repair and replacement of parts should be initiated only after the defective part or assembly has been isolated by good troubleshooting methods. The recorder has been designed to make most servicing possible with a minimum of difficulty.

CAUTION

Use a soft rubber pad under the recorder during service to prevent damage to paint and exterior parts.

5-95. CONTROL PANEL REMOVAL.

NOTE

The control panel must be removed for most service functions since the majority of the circuit boards are located under it, and because the transport cannot be opened with the control panel in place.

5-96. Remove the control panel by using the following procedure:

a. Remove power cord.

b. Remove the seven screws which hold it in place (see Figure 5-27).

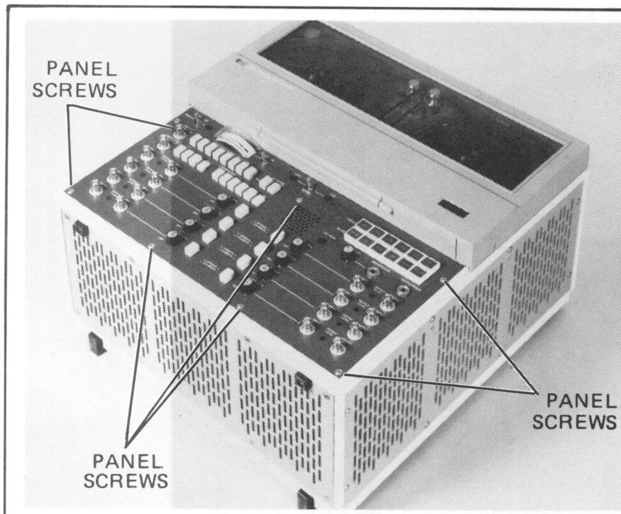


Figure 5-27. Control Panel Removal

c. Lift the bottom of the panel up until panel is free.

d. Lift panel free of recorder.

NOTE

Position the panel where the labeling can be read. Not all of the control switches and potentiometers are labeled on the module sub-panels.

NOTE

Before replacing control panel, check to make sure that all modules are securely in place. All modules except the SPEED and MODE are held in place with two screws; one on each side.

e. Replace the control panel by inserting the top of the panel under the bottom transport edge with the panel bottom lifted up at about 45 degrees (see Figure 5-28). Then lower the panel bottom slowly while aligning the pushbuttons or knobs with the corresponding panel clearance holes. When the panel is in position, secure with the seven screws.

5-97. TOP AND BOTTOM COVER REMOVAL.

5-98. Removal of the top and bottom covers is accomplished by removing the screws identified in Figure 5-29.

CAUTION

Make sure that the same length screws are used to replace the top cover. Screws which are too long may cause circuit board damage.

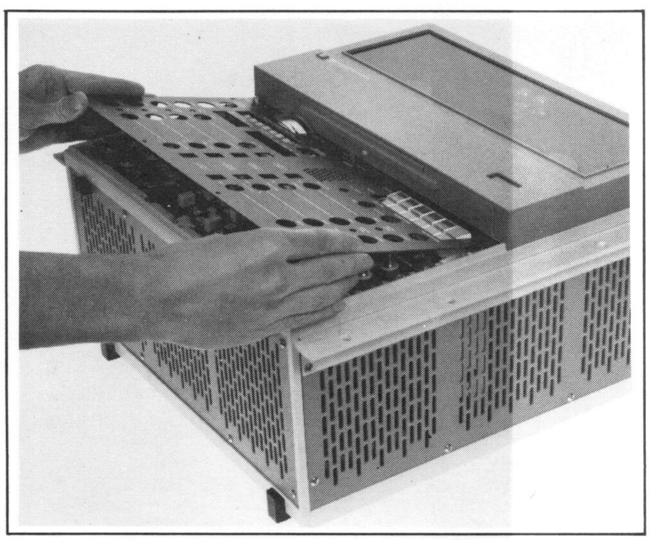


Figure 5-28. Control Panel Replacement

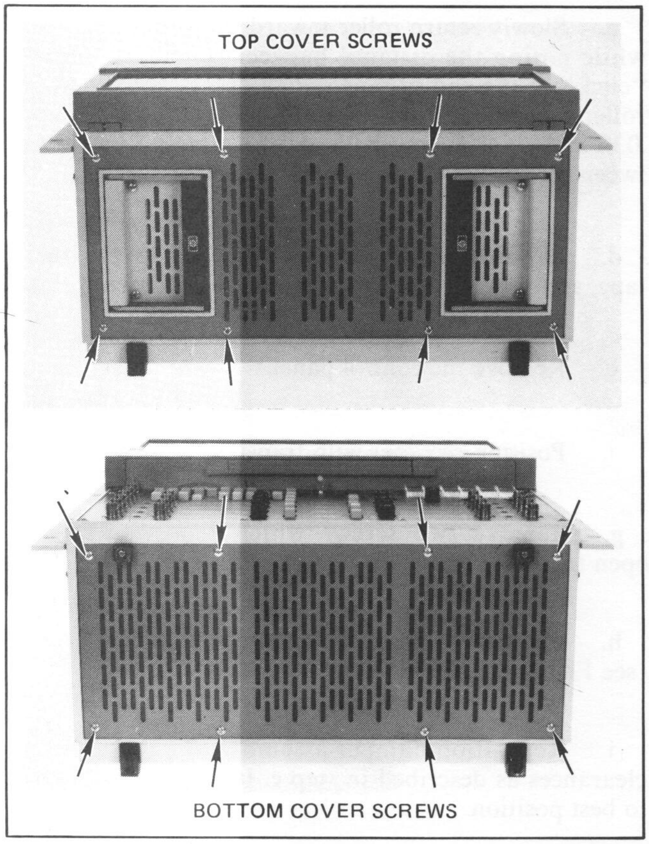


Figure 5-29. Top and Bottom Cover Removal

5-99. RACK EAR AND SIDE COVER REMOVAL.

5-100. The side covers must be removed to gain access to Regulator PCA's A1 and A2 and to several printed circuit adjustments. Remove as follows:

a. Remove the rack mounting ears, if they are installed. Their screws are accessible from the sides (see Figure 5-30).

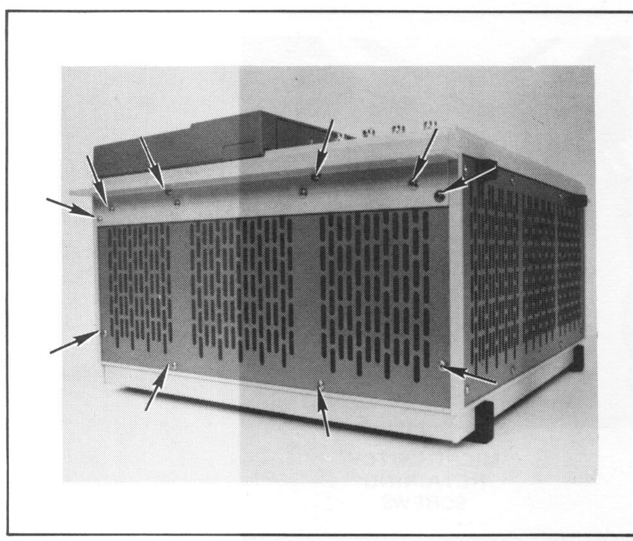


Figure 5-30. Rack Ear and Side Cover Removal

b. Remove the remaining screws from the side covers. The covers are now free.

c. Replace in reverse order.

5-101. REAR COVER REMOVAL.

5-102. Rear cover removal is normally not necessary unless it is necessary to gain access to the bottom of Interconnect PCA A24 for testing or soldering. The cover is secured by the screws as identified in Figure 5-31. The rear connector wires from Option 003 recorders must be carefully disconnected from the Interconnect PCA (A24).

5-103. CARRYING HANDLE REMOVAL.

5-104. The handle assembly has a captive spring which returns it to the flush position when released. The handle is disengaged by removing two screws and a cover plate (see Figure 5-32).

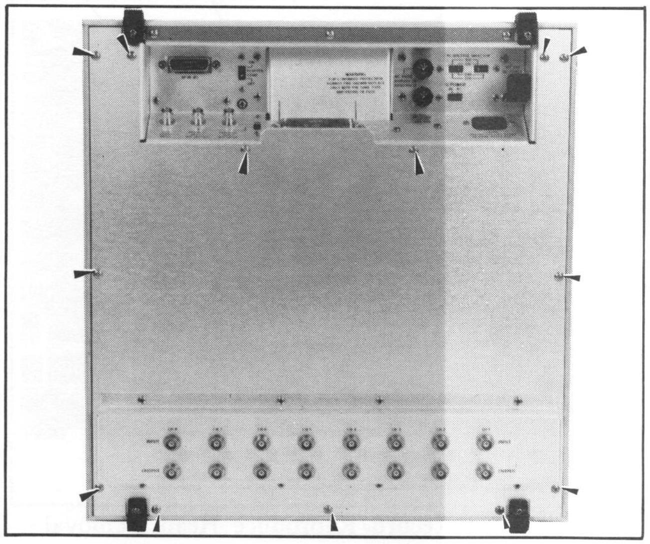


Figure 5-31. Rear Cover Removal

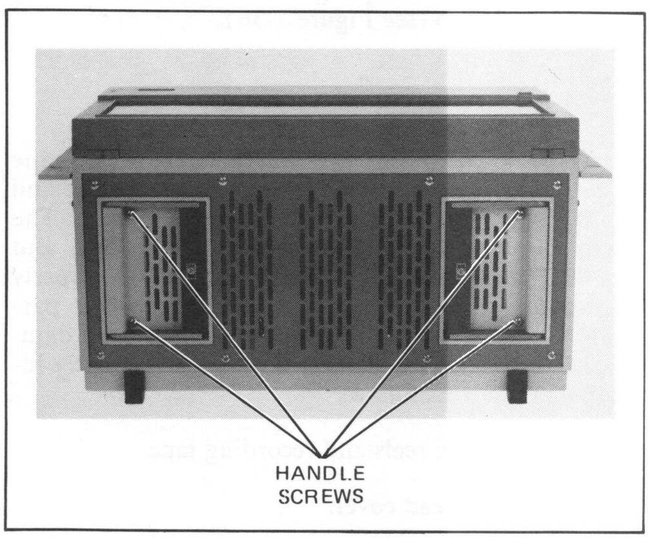


Figure 5-32. Carrying Handle Removal

5-105. REEL COVER REMOVAL.

5-106. It normally is not necessary to remove the reel cover unless it is necessary to rest the recorder on its top (the handles down) or if the cover needs to be replaced. Proceed as follows:

a. Position recorder on its rear feet.

b. Remove the outside screws from each hinge (see Figure 5-33).

c. Remove the screw and bushing from the reel cover stop mechanism where it is attached to the recorder side casting.

d. Remove the remaining two hinge screws while holding the reel cover from falling.

e. Lift the cover free of the recorder.

f. Replace cover by reversing foregoing procedures.

5-107. HEAD COVER REMOVAL.

5-108. The head cover is opened by lifting upward on the top and swinging down to provide access to the recording head area (see Figure 5-34). Removal is not normally necessary, but can be accomplished by removing the four screws which secure it at the bottom.

5-109. RECORD AND REPRODUCE HEAD REMOVAL.

5-110. Most head problems can be corrected by cleaning, but the abrasive action of the recording tape moving over the head surface will eventually degrade head performance until replacement is necessary. Use the following procedure to replace a head:

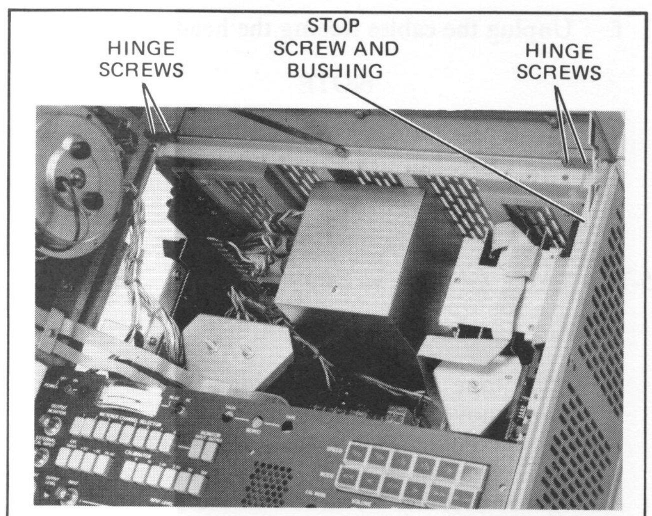


Figure 5-33. Reel Cover Removal

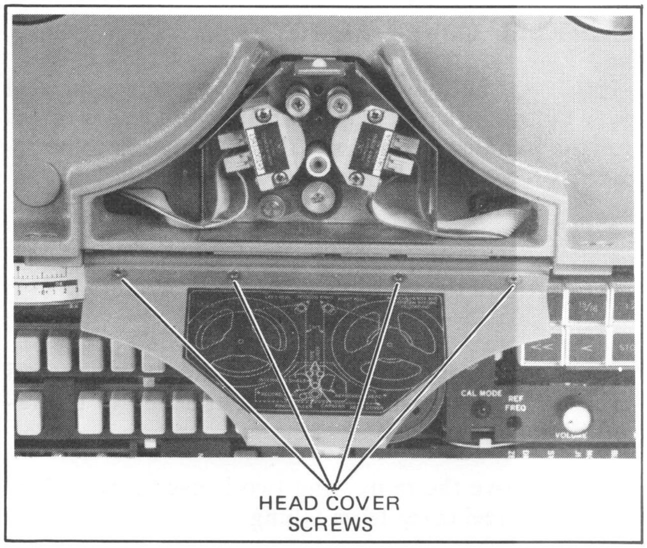


Figure 5-34. Head Cover Removal

CAUTION

The record and reproduce heads require special care. Never allow a sharp, hard object to come into contact with the polished surface. Scratches can degrade head performance.

a. Remove reels and recording tape.

b. Open head cover and remove interhead shield from between heads (see Detail A; Figure 5-35).

c. Remove the two screws from the head (see Detail B, Figure 5-35).

d. Carefully lift the head up far enough to easily unplug the cables.

e. Note the orientation of the cables on the head (see Detail B, Figure 5-35).

f. Unplug the cables freeing the head.

NOTE

To replace a head, reverse the foregoing procedures. There is no alignment procedure required for a new head.

5-111. TAPE GUIDE REMOVAL.

NOTE

The tape guides are designed so the tape moves across a very small surface on the guide. This surface can wear after extensive recorder operation. If the guide becomes worn, loosen the retaining screw and turn the guide to a different position and retighten.

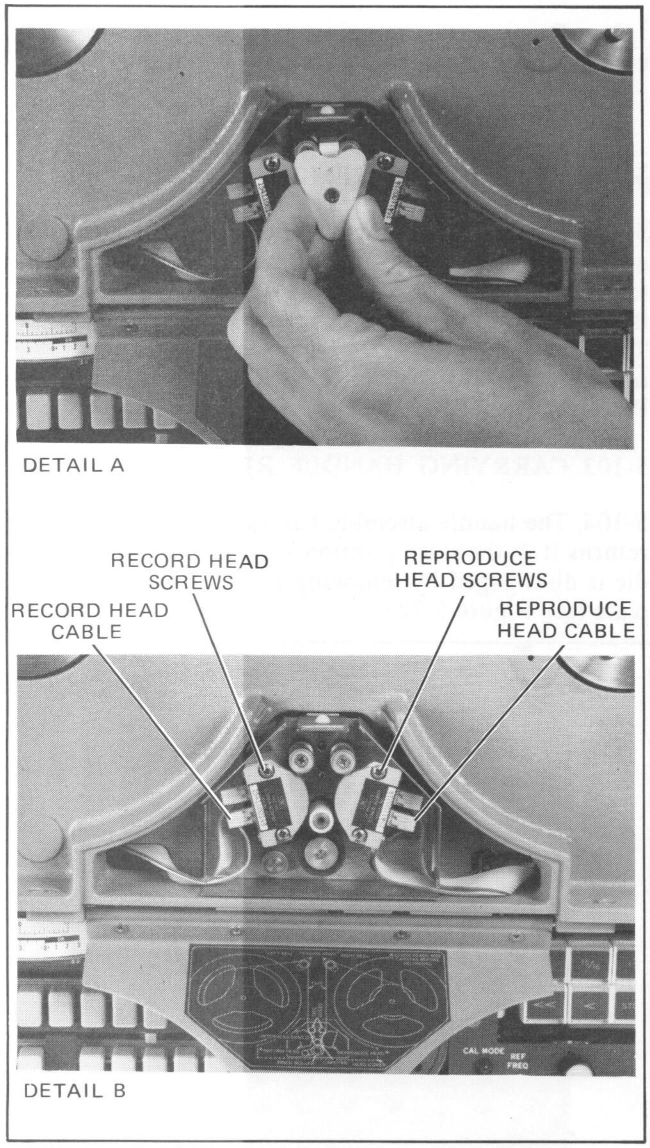


Figure 5-35. Record/Reproduce Head Removal

5-112. To replace a tape guide loosen the holding screw from the top (see Figure 5-36).

5-113. PINCHROLLER REMOVAL.

5-114. The pinchroller presses the recording tape against the capstan surface during forward, reverse and RECORD modes to eliminate tape slippage. The pinchroller and capstan surfaces must be clean and smooth. The pinchroller solenoid must also be properly adjusted for proper pinchroller operation (refer to paragraph 5-82). If the pinchroller surface has been damaged or the bearing is defective (it is permanently lubricated) replace as follows:

a. Remove the reels and recording tape.

b. Open the head cover.

c. Remove the retaining ring (see Figure 5-37).

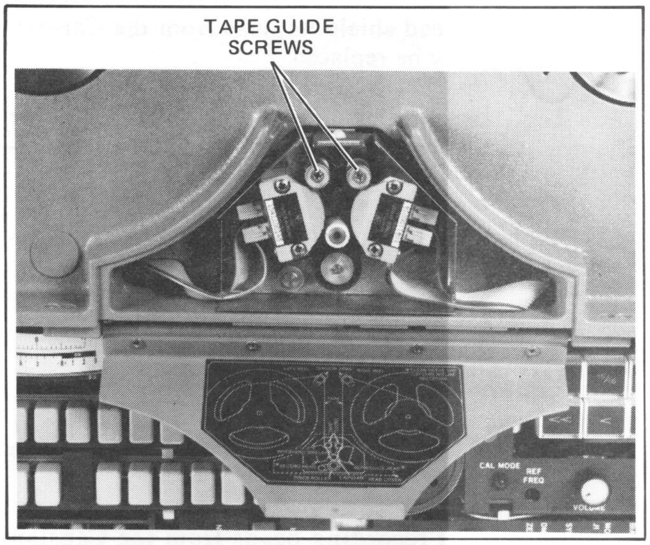


Figure 5-36. Tape Guide Removal

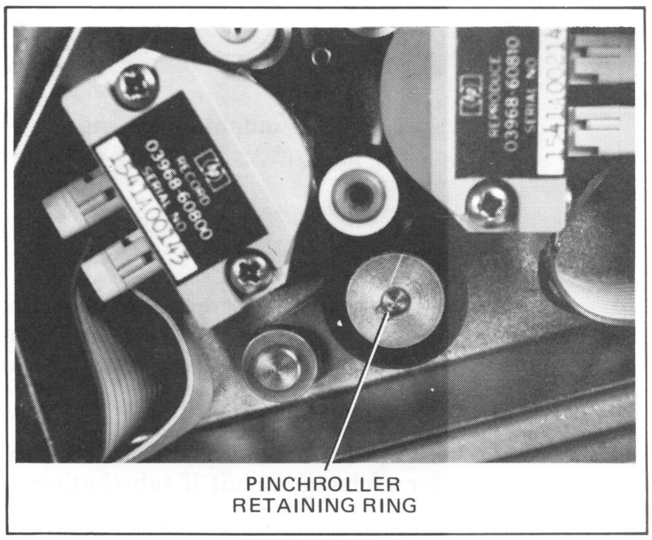


Figure 5-37. Pinchroller Removal

d. Carefully lift off the cap, pinchroller, and any shims provided.

NOTE

Use the same shims when installing the new pinchroller to ensure correct pinchroller to capstan clearance but a new retaining ring should be used when reassembling.

5-115. TAPE TRANSPORT HANDLING.

WARNING

The transport should not be opened with the recorder in a vertical position unless the unit is rack mounted, or has other means of support to prevent tipping. The transport is heavy and could cause personal injury if allowed to accidently fall.

5-116. The tape handling mechanism, the preamplifier assembly, and wiring harness are located in the transport. To gain access to these units open the transport as follows:

a. Lay recorder horizontally on bench with the tape transport facing upward.

b. Open the reel cover.

c. Remove the control panel (paragraph 5-90).

d. Remove the two screws from the right side of the transport (see Figure 5-38).

e. Lift transport open on its hinge until the stop mechanism prevents further opening.

NOTE

A grove is provided to grasp lower right edge of transport and lift open.

f. Verify that latch is dropped into locked position.

g. Close the transport in reverse order.

5-117. PINCHROLLER SOLENOID REMOVAL.

5-118. The pinchroller solenoid can be replaced without removing the capstan. Follow the procedure below:

a. Remove the power cord.

b. Remove the control panel (paragraph 5-90).

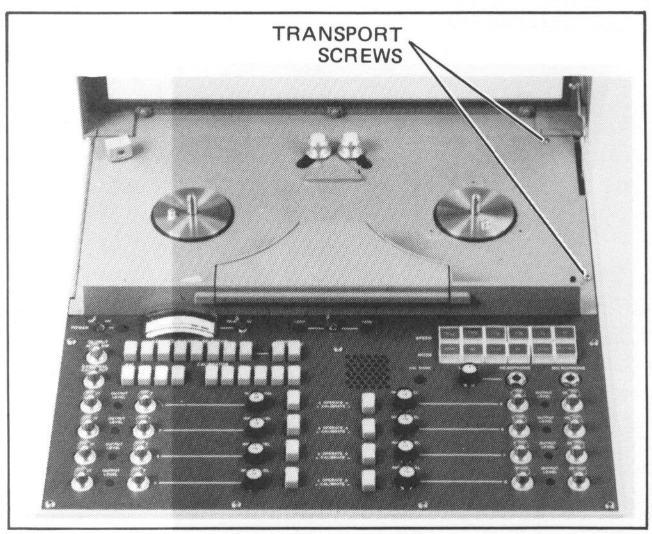


Figure 5-38. Tape Transport Handling

c. Open the tape transport (paragraph 5-110).

d. Cut pinchroller solenoid wires at a convenient place. The new solenoid will be spliced onto the old wires from the capstan connector.

e. Using long-nosed pliers, unhook the pinchroller pressure spring from the groove pin on the solenoid actuator arm (see Figure 5-39).

f. Remove screws and washers securing solenoid to solenoid bracket.

g. Slide the solenoid free of the bracket.

NOTE

The pinchroller solenoid should not be oiled. For proper operation the plunger must be dry.

h. Remove the grove pin and compression spring from the old solenoid and install them on the new solenoid.

i. Install the new solenoid by reversing the removal procedures. Refer to paragraph 5-82 for pinchroller solenoid adjustments.

5-119. CAPSTAN ASSEMBLY REMOVAL.

5-120. The Capstan Assembly includes the capstan, capstan motor, optical tachometer, interhead shield, pinchroller, pinchroller solenoid and associated parts. If the capstan, capstan motor, or optical tachometer need repair, the complete Capstan Assembly is available as a rebuilt item (the standard capstan assembly is P/N 03968-62700 or the Option 041 capstan is P/N 03968-62710). Internal field repair is not recommended, but the following service of the external Capstan Assembly parts can be performed.

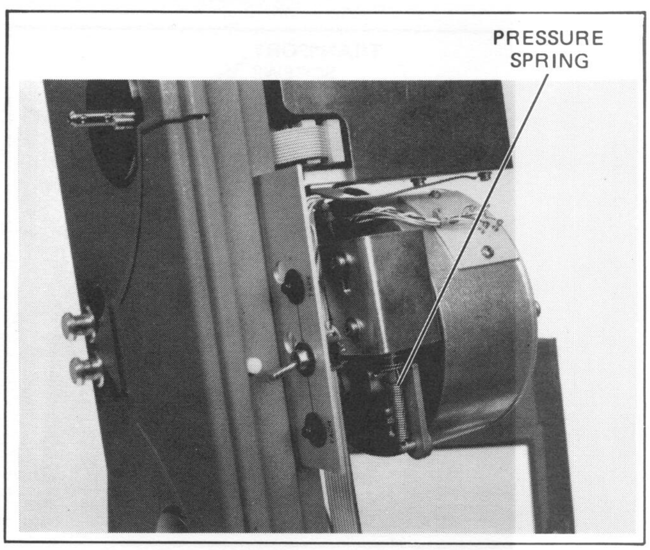


Figure 5-39. Pinchroller Solenoid Removal

a. The interhead shield unplugs from the Capstan Assembly and may be replaced.

b. The pinchroller (paragraph 5-108) or pinchroller solenoid (paragraph 5-112) can be replaced or adjusted (paragraph 5-82).

5-121. Replace the Capstan Assembly using the following procedure:

a. Unplug the power cord.

b. Remove the reels and recording tape.

c. Remove the control panel. Refer to paragraph 5-95.

d. Detach the recording heads from the Capstan Assembly. Refer to paragraph 5-109.

e. Open the tape transport as described in paragraph 5-115.

f. Unplug the preamplifier output cables and reposition the cables to clear the capstan mounting to facilitate removing the capstan.

g. Disconnect the main capstan plug.

h. Remove the four mounting screws that hold the capstan assembly to the transport. Support the capstan with one hand to prevent it from falling (see Figure 5-40).

i. Remove the Capstan Assembly and return it to Hewlett-Packard for exchange credit if substituting a rebuilt assembly.

j. Install the replacement Capstan Assembly using reverse of the procedure used in removal.

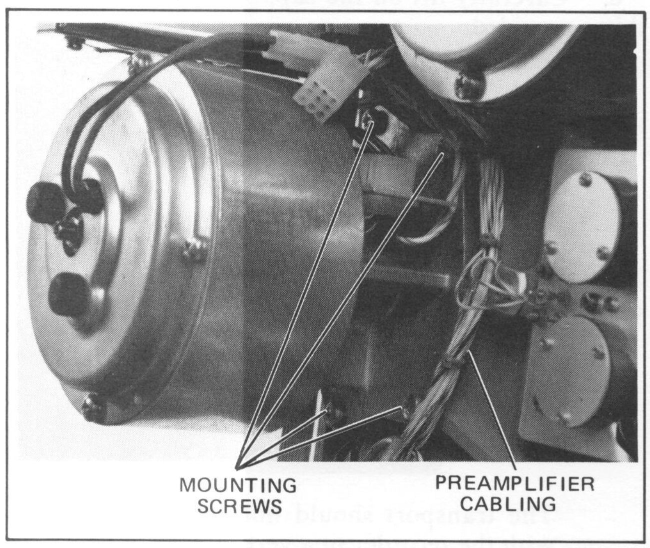


Figure 5-40. Capstan Assembly Removal

5-122. REEL MOTOR DISASSEMBLY.

5-123. Both reel motors are identical and interchangeable. If a motor is not performing properly, cleaning the brush deposit from the armature with Freon may restore the performance. When motor service is necessary use the following procedure:

a. Remove the power cord, reels and recording tape.

b. Position recorder flat on bench with tape transport facing upward.

c. Remove control panel as described in paragraph 5-95.

d. Open the tape transport. Refer to paragraph 5-115.

e. Unplug the two pin connector from the motor.

f. Remove the three mounting screws and lock washers which secure motor assembly to the transport (Figure 5-41; items 8 and 9).

g. Carefully insert a slim blade screwdriver between the motor halves (see Figure 5-42) and turn blade 90 degrees to separate motor halves (Figure 5-41; items 10 and 12).

WARNING

The motor armature can be easily damaged or injury can result if the motor is separated improperly. Work the screwdriver between the halves carefully. Do not force or allow the screwdriver to extend further into the motor than the mounting flange. A very strong permanent magnet in the outer motor cover (Figure 5-41; item 10) of the motor assembly holds the motor tightly together. If a tool is forced between the halves, the motor may separate suddenly.

h. Completely lift off the outer motor cover (Figure 5-43).

NOTE

The inner rotor surface, which acts as a commutator, is now visable for inspection. If it appears to be severely worn proceed with step i. and replace the motor assembly. If cleaning is dictated, spray the commutator with Freon or a similar cleaner and reassemble the motor.

i. To proceed with motor replacement, remove the motor shaft nut (Figure 5-41, item 1) with a 3/8-inch box end wrench while holding the motor shaft with a large straight blade screwdriver.

j. Note the position of the motor base on the transport and carefully lift off lock washer, rotor, and motor base (Figure 5-40; items 2, 11, and 12). Leave upper shims and spacer on shaft.

k. Disassemble new motor assembly as the original motor was separated in step g. and h.

l. Mount the new motor base temporarily to the transport (see Figure 5-44).

NOTE

The following procedure ensures correct rotor centering between the motor cover and motor base (Figure 5-41; items 10 and 12). The rotor is shimmed for approximately .021 to .024-inch clearance from the motor base (Figure 5-40, item 12). Two types of shims should be used, HP P/N 3050-0603 for .005-inch and HP P/N 3050-0470 for .010-inch.

m. Remove two thick upper shims (.010-inch each).

n. Temporarily install rotor with nut and lock washer (Figure 5-41; items 11, 1, and 2).

o. Install empty reel on hub.

p. Release brakes by manually depressing brake solenoid and spin reel listening for scraping sounds or noting excessive friction (see Detail A, Figure 5-25).

NOTE

If the rotor scrapes remove the rotor, add a .005-inch shim. Reinstall the rotor and try step p. again. When it clears, add two thick shims (.020-inches) and proceed to step q.

NOTE

If the rotor moves without stopping, remove a .005-inch shim and try step p. Repeat this removal process of shims (.005 inches thickness at a time) until the rotor scrapes. At this point add two thick and one thin shim (.025-inches); thus ensuring correct clearance.

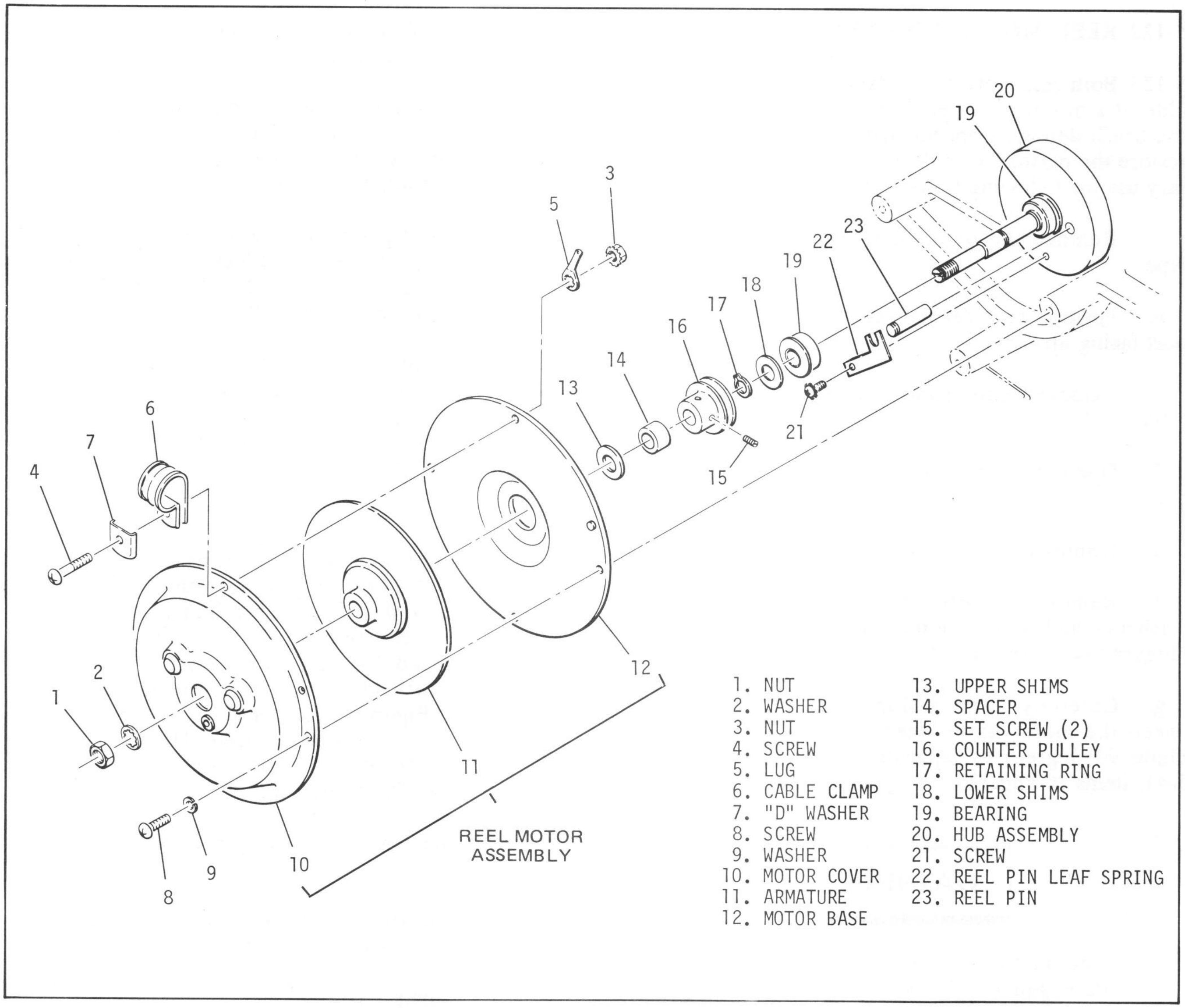


Figure 5-41. Reel Motor Assembly, Exploded View

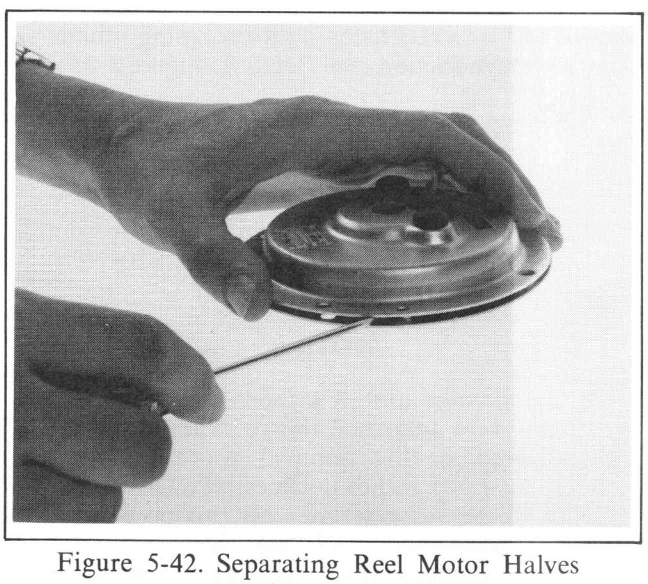


Figure 5-42. Separating Reel Motor Halves

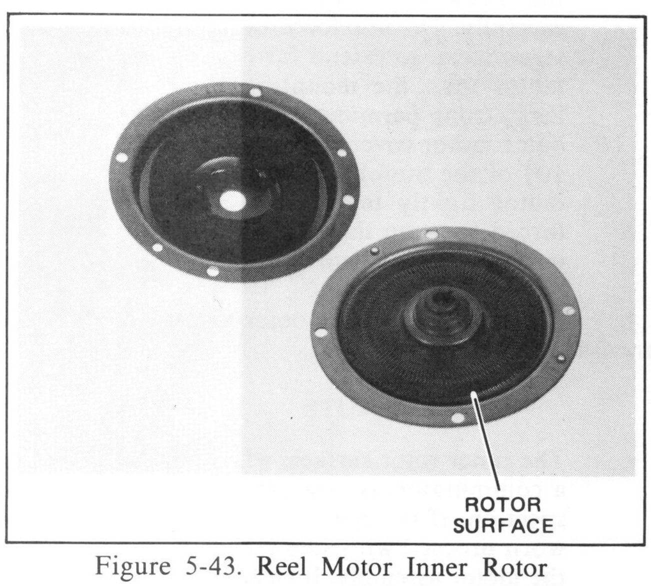


Figure 5-43. Reel Motor Inner Rotor

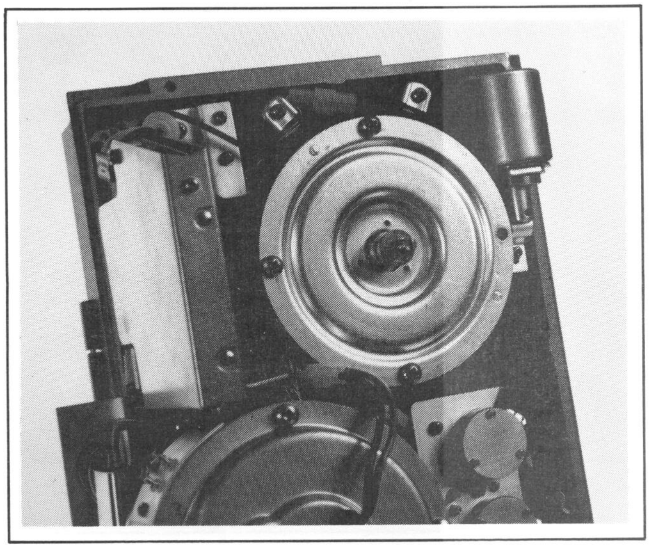


Figure 5-44. Reel Motor Base Mounting

q. Remove the three screws which temporarily mounted the motor base to the transport.

r. Reassemble the motor reversing the steps used in disassembly.

5-124. REEL HUB AND SHAFT REMOVAL.

5-125. To service the reel hub and shaft mechanism disassembly may be required. As an example, the bearing (Figure 5-41; item 19) requires complete disassembly to replace. Proceed as follows:

a. Remove the reel motor associated with the reel hub that needs service.

b. Remove the upper shims and spacer (Figure 5-41; items 13 and 14).

c. On the right reel hub and shaft only, remove the counter pulley (Figure 5-41, item 16). It is secured with two setscrews (Figure 5-41, item 15). Refer to Figure 5-45. Also remove the counter drive belt.

d. Remove retaining ring (see Figure 5-46) and lower shims (Figure 5-41; item 17 and 18). Retain shims for reassembly.

CAUTION

The brake bands can be bent if the reel hub and shaft assemblies are forced out with the brakes applied.

e. Release the brakes by manually depressing the brake solenoid plunger. With brakes released, pull hub and shaft from recorder (refer to Figure 5-46).

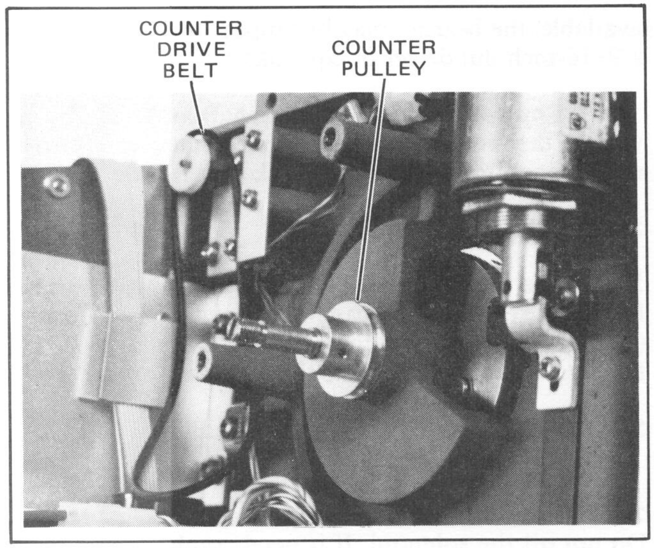


Figure 5-45. Reel Motor Counter Pulley Removal

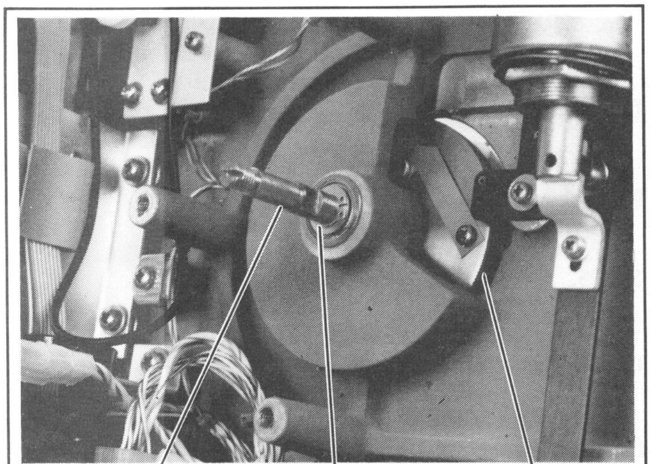


Figure 5-46. Reel Motor Hub and Shaft Removal

NOTE

The reel pin leaf spring can now be easily replaced (Figure 5-41, item 22). It is secured with a screw (item 21). If the ball bearings are worn, tap them out with any convenient tool. The bearings will not be usable after removal.

CAUTION

The ball bearings used on the hub and shaft are easily damaged. Use extreme care when installing. Apply force only to the outer race. They are permanently lubricated; do not lubricate.

f. Install the new bearings by pressing the outer bearing race into the casting. If a special tool is not

available, the bearing may be tapped into position with a 9/16-inch nut driver or equivalent.

g. Replace the reel hub and shaft assembly by reversing the removal procedure. Check the end play and use lower shims as required to take out the looseness.

5-126. REEL BRAKE REPAIR.

5-127. The reel brakes normally do not require repair. Most brake problems can be corrected by cleaning (paragraph 5-11) or adjustment (paragraph 5-89). If further service is needed use the following procedures.

5-128. REEL MOTOR BRAKE SOLENOID REPLACEMENT.

5-129. The solenoid should operate with a dry plunger. Do not oil the solenoid. If it needs replacement, proceed as follows:

a. Remove the power cord.

b. Position recorder on rear feet with transport facing up.

c. Remove front control panel as described in paragraph 5-95.

d. Open the tape transport. Refer to paragraph 5-115.

e. Disconnect solenoid from wiring harness using the two pin connector.

f. Remove the 1-1/8-inch hex nut and lock washer from the brake solenoid (see Figure 5-47).

NOTE

If a wrench is not available that will permit removal of the brake solenoid nut with the clearance provided, the right reel motor must be removed. Use the procedure in paragraph 5-122.

g. Carefully work the solenoid coil from the bracket and plunger.

h. Remove the solenoid plunger from the brake mechanism.

i. Install the new brake solenoid by reversing the disassembly steps.

j. Recheck the brake operation and adjust as required. Refer to paragraph 5-89 for adjustment procedures.

5-130. BRAKE LINKAGE REMOVAL.

5-131. To remove the brake linkage use the following procedure:

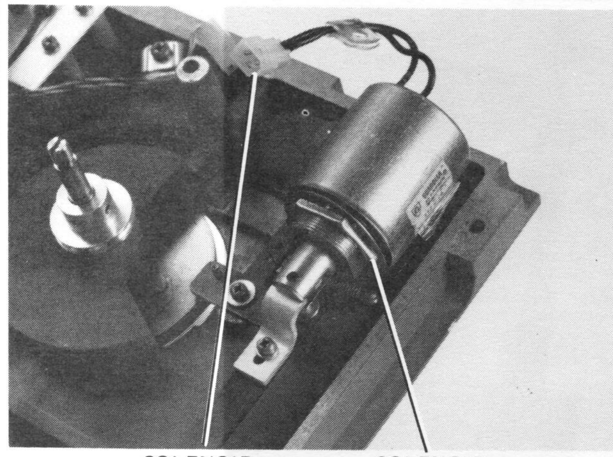


Figure 5-47. Reel Motor Brake Solenoid Removal

a. Remove both reel motors as described in paragraph 5-122.

b. Remove the brake solenoid. Refer to paragraph 5-128.

c. Remove the reel cover. Refer to paragraph 5-105.

d. Remove the solenoid linkage as shown in Figure 5-48.

e. Remove the long brake arm. It is connected to the right and left bell cranks with the screws and nuts as indicated (see Figure 5-49). Use a box end wrench to hold the nuts.

f. Remove the extension springs from each bell crank as illustrated in Figure 5-50. Notice holes where springs are terminated for future reference.

CAUTION

Be careful not to bend the brake band assembly when brake bell crank is pulled out of eyelets in brake bands.

g. Remove the bell cranks. They are attached to the transport with screws, washers, and bushings (see Figure 5-51). Hold brake band near eyelet while lifting bell crank free.

h. Reassemble brake linkage by reversing the previous disassembly steps.

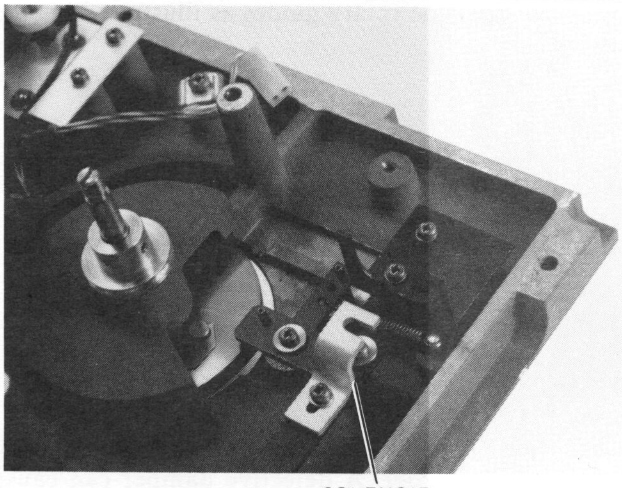


Figure 5-48. Solenoid Linkage Removal

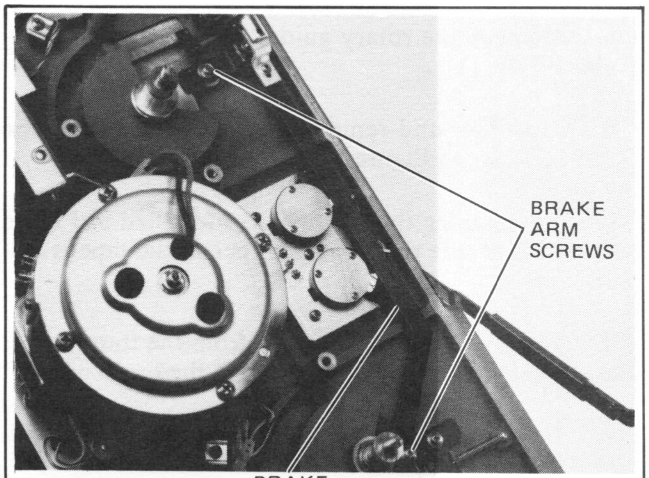


Figure 5-49. Brake Arm Removal

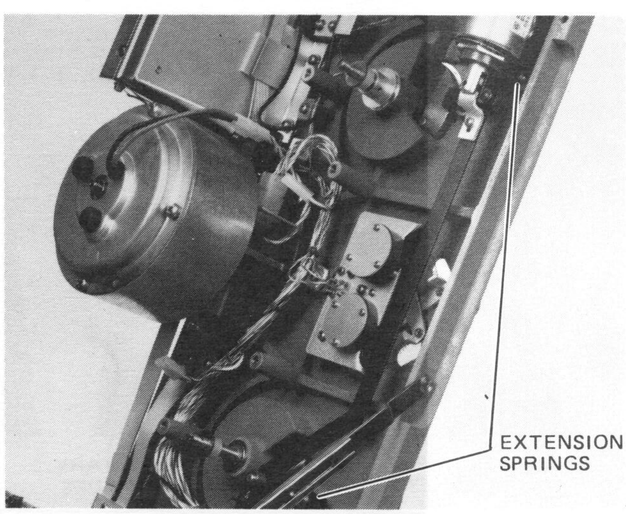


Figure 5-50. Bell Crank Extension Spring Removal

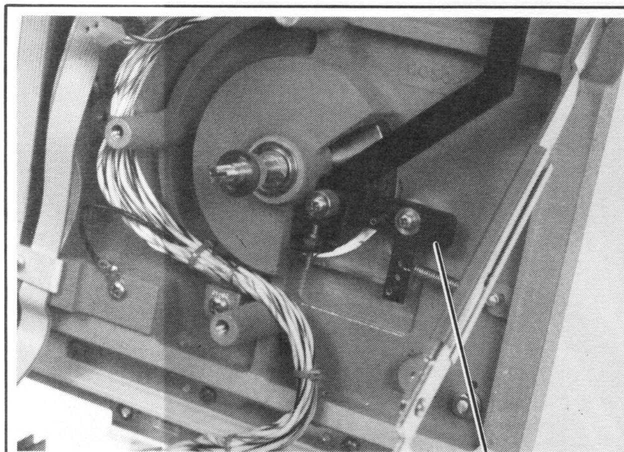


Figure 5-51. Bell Crank Removal

NOTE

When assembling be careful to install the bell crank springs into the same holes which were used for the original installation. It is easier to install a spring onto the bell crank before the dowel pin. Also ensure that the bushings used in each bell crank and in each end of the brake arm do not bind. If these parts are not free to pivot at each bushing, a satisfactory brake adjustment cannot be made.

i. Adjust the brakes as described in paragraph 5-89.

5-132. BRAKE BAND REPLACEMENT.

5-133. Use the following procedure to replace the brake bands:

a. Remove both reel motors (paragraph 5-122).

b. Remove both reel hub and shaft assemblies (paragraph 5-124).

c. Remove brake solenoid. Refer to paragraph 5-117.

d. Remove brake linkage (refer to paragraph 5-130).

e. Remove the bands through the top of the transport as illustrated in Figure 5-52.

f. Reassemble reel brake assemblies by reversing the above steps.

g. Adjust brakes as described in paragraph 5-89.

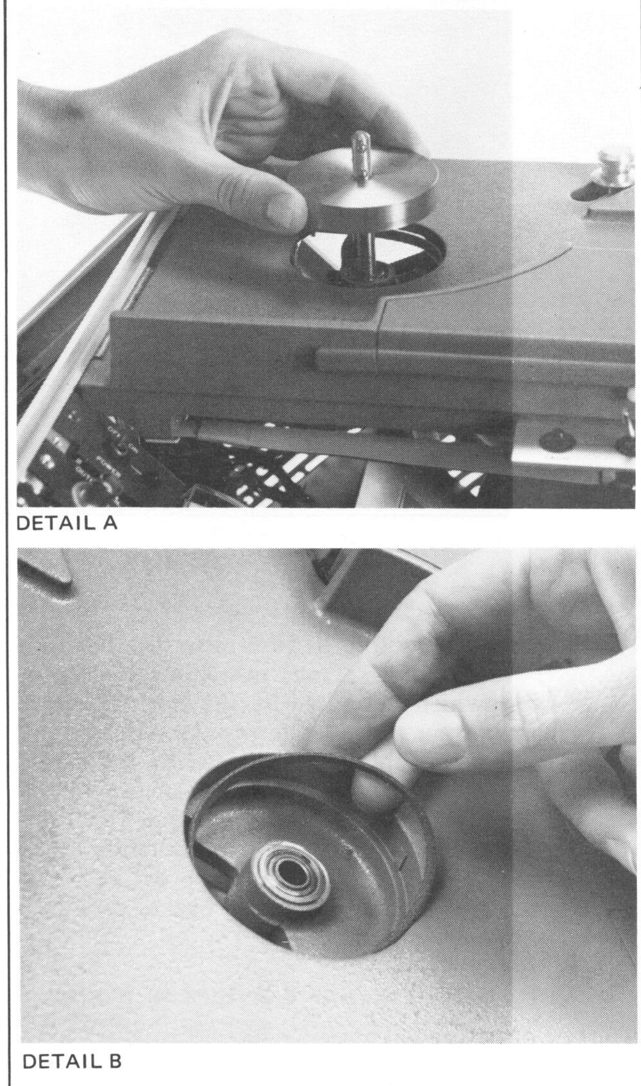


Figure 5-52. Brake Band Removal

h. Complete reassembly of recorder and check out transport operation thoroughly.

5-134. ROTARY GUIDE REMOVAL.

5-135. Normal maintenance of the rotary guides consists of cleaning the tape path surface. The bearing is permanently lubricated, therefore no lubrication is required. Replace a rotary guide as follows:

a. Remove the power cable.

b. Remove the tape reels and recording tape.

c. Remove the control panel as described in paragraph 5-95.

d. Open the tape transport. Refer to paragraph 5-115.

e. Remove the rotary guides as illustrated in Figure 5-53.

NOTE

The guide mount has a hole drilled through it. An Allen wrench can be inserted into the guide mount hole to prevent twisting while removing with a screwdriver.

5-136. TAPE DAMPER REMOVAL.

5-137. The Tape Damper Assembly is a critical component of the recorder. A defective damper can cause flutter problems or other tape handling errors such as the inability to develop an End Of Tape (EOT) command. Replace the Tape Damper Assembly as follows:

a. Remove the rotary guides as described in paragraph 5-134.

b. Unsolder and remove the wires from the Tape Damper. Refer to Figure 5-53.

c. Remove the three screws as identified in Figure 5-53 which secure the Tape Damper to the tape transport.

d. Remove the Tape Damper from the transport. It must be eased carefully from beneath the brake arm.

e. Install the new Tape Damper Assembly with care. The new damper arms must not be bent.

f. Adjust the End of Tape switches as described in paragraph 5-91.

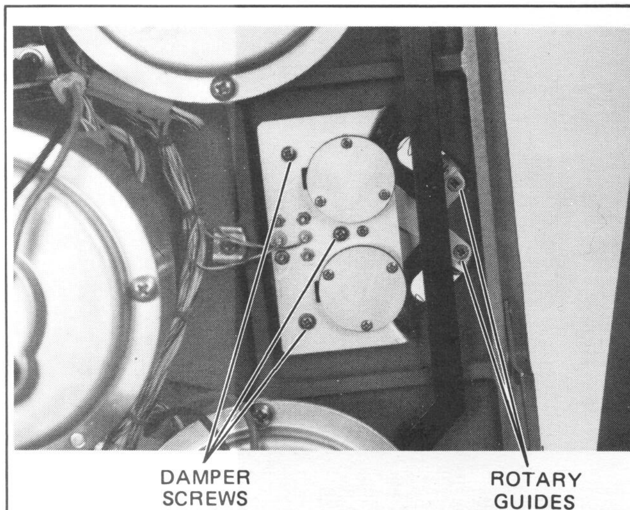


Figure 5-53. Rotary Guide and Tape Damper Removal

5-138. REEL REVOLUTION COUNTER REMOVAL.

5-139. The Reel Revolution Counter is driven by a belt from a pulley on the right Reel Hub and Shaft. To allow belt replacement, the Reel Motor must be removed as described in paragraph 5-122. To replace the Reel Revolution Counter proceed as follows:

a. Remove the power cord.

b. Remove the control panel. Refer to paragraph 5-85.

c. Open the Tape Transport as described in paragraph 5-115.

d. Remove the drive belt from the Reel Revolution Counter pulley. The belt is elastic and can easily be pulled from the pulley (see Figure 5-54).

e. Remove the counter and bracket from the transport. The two screws which secure the bracket are identified by arrows in Figure 5-54.

5-140. POWER TRANSFORMER REMOVAL.

5-141. The Power Transformer can be replaced as follows:

a. Remove the power cable.

b. Remove the control panel. Refer to paragraph 5-95.

c. Remove +5V(B) Regulator PCA A1 (refer to paragraph 5-154).

d. Remove the top cover as described in paragraph 5-97.

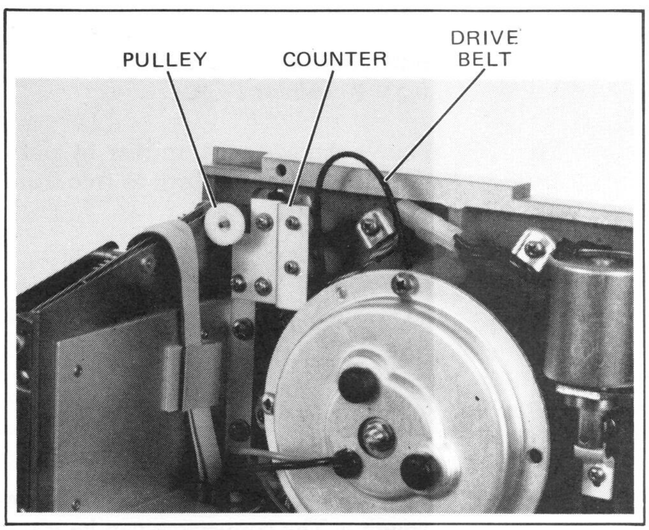


Figure 5-54. Reel Revolution Counter Removal

e. Remove the left carrying handle (refer to paragraph 5-103).

f. Remove the transformer wires. Unsolder, unplug and clip wires as required carefully noting the connection points and corresponding wire colors.

NOTE

The transformer can now be removed. Remove the four screws which mount it to the top frame as illustrated in Figure 5-55. Lift free of recorder.

WARNING

Incorrect transformer wiring may endanger the operator or damage the recorder. Connect the replacement transformer wires as the original transformer was installed.

g. Install the new power transformer by reversing the preceeding removal steps.

5-142. CALIBRATOR, VOICE, SERVO AND DATA PCA REMOVAL.

NOTE

The Data Card Extender Board (HP P/N 03968-60965) may be used in the repair of the Calibrator, Voice, Servo and Data PCA's.

5-143. Use the following procedure to remove any of the identified printed circuit assemblies (PCA's):

a. Disconnect the power cord.

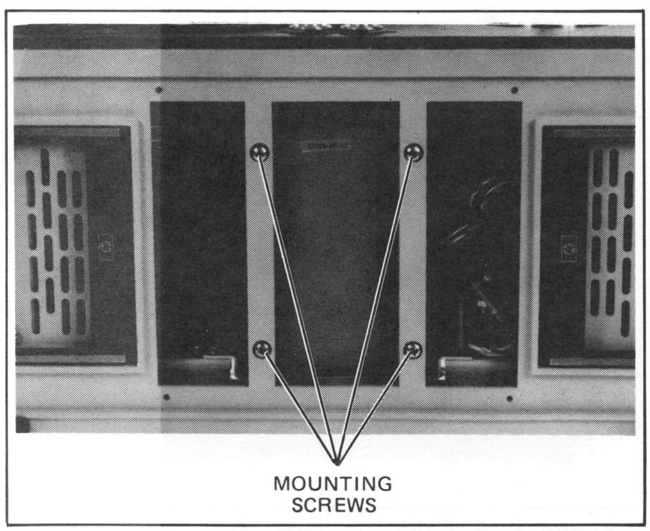


Figure 5-55. Power Transformer Removal

b. Remove the control panel as described in paragraph 5-95.

c. Identify the PCA to be replaced as illustrated in Figure 5-56.

d. Remove the screw from each side.

e. Lift extractor ring from concealed to extended position with fingernail or flat bladed screwdriver (see Figure 5-56).

f. Pull outward on extractor to remove assembly. If assembly is jammed, try a small back and forth movement to the side while pulling outward.

NOTE

No side guides are provided for these PCA's. If connector alignment is difficult, try removing the side cover (paragraph 5-99), and align visually.

g. To install PCA, push extractor into concealed position, align connectors, and push PCA on outer corners.

5-144. METER SELECT/POWER DETECTOR PCA REMOVAL.

5-145. To remove the PCA for service proceed as follows:

a. Disconnect the power cord.

b. Remove the control panel as described in paragraph 5-95.

c. Remove the two screws from each side of the panel (see Figure 5-57).

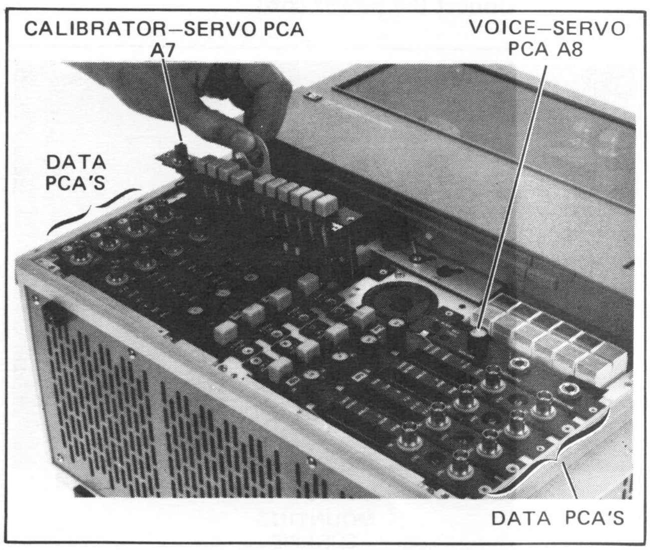


Figure 5-56. Calibrator-Servo PCA, Voice-Servo PCA and Data PCA Removal

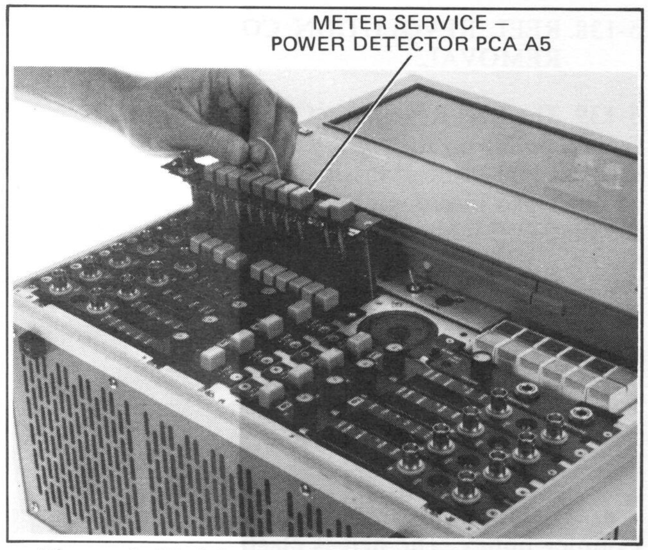


Figure 5-57. Meter Select/Power Detector PCA Removal

d. Use extractor ring to remove the PCA.

NOTE

The Data Card Extender Board (HP P/N 03968-60965) can be used with this PCA.

e. Reinstall as is described in step g., paragraph 5-143.

5-146. METER AMPLIFIER/10.5V REGULATOR PCA REMOVAL.

5-147. Use the following procedure to service the Meter Amplifier PCA:

a. Remove the Meter Select/Power Detector PCA (refer to paragraph 5-144).

b. Remove the two screws from each side of the Meter Amplifier/10.5V Regulator PCA.

c. Manually remove the Meter Amplifier by pulling outward while moving back and forth to free from connector (see Figure 5-58).

NOTE

The Meter Amplifier may be extended by using the HP Part No. 03968-60960 extender board with the tape transport open. Refer to paragraph 5-105.

d. Reinstall the Meter Amplifier by reversing the removal steps a. through c. The connectors can be visually aligned by using the Meter Select PCA opening.

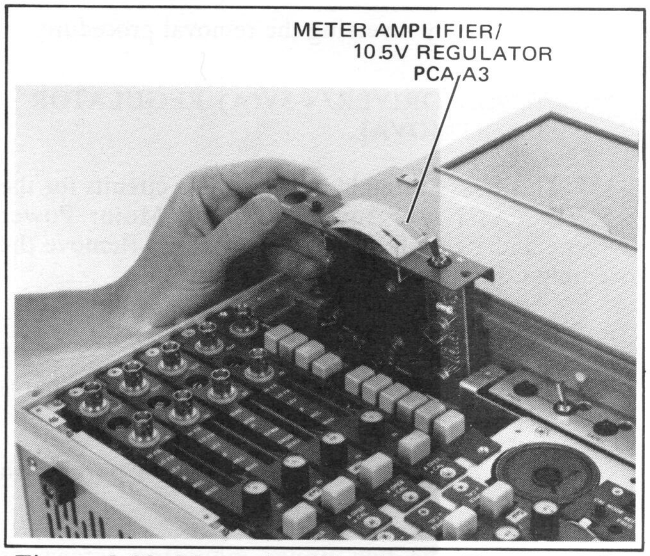


Figure 5-58. Meter Amplifier/Power Detector PCA Removal

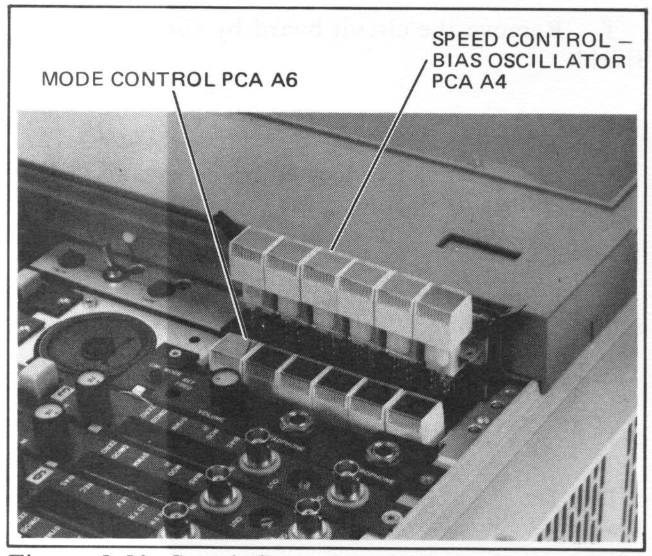


Figure 5-59. Speed Control and Mode Control PCA Removal

5-148. MODE CONTROL PCA REMOVAL.

5-149. The Mode Control PCA is marked "MODE" on the control panel. It contains much of the control logic circuitry for the recorder. An extender board is provided for troubleshooting (HP Part No. 03968-60960). Use the following procedure to remove the PCA for service:

a. Disconnect the power cable.

b. Remove the control panel as described in paragraph 5-95.

c. Remove the PCA. Black plastic extractor tabs are provided (see Figure 5-59).

NOTE

MODE light bulbs may be replaced after removing the control logic PCA. The pushbutton can be pulled free of the mount to provide access to the plug in bulb.

d. Replace by reversing the removal steps.

5-150. TAPE SPEED CONTROL/BIAS OSCILLATOR PCA REMOVAL.

5-151. The PCA is marked "SPEED" on the control panel. It may be serviced by using the same extender board and service procedure which was used for Mode Control PCA A6 (refer to paragraph 5-148).

5-152. PREAMPLIFIER PCA REMOVAL.

5-153. The Preamplifier PCA provides preamplification for the reproduce amplifiers on the data PCA's. The preamplifier output signals may be monitored at the eight test points provided at the circuit board edge. Remove the preamplifier PCA as follows:

a. Remove power cable.

b. Remove the control panel as illustrated in paragraph 5-95.

c. Open the tape transport to gain access to the preamplifier. Refer to paragraph 5-115.

d. Unplug the cables from the preamplifier PCA. The two smaller plugs are from the reproduce head. The output plug is the larger plug located near the test points (see Figure 5-60).

e. Remove the retaining screw as illustrated in Figure 5-60.

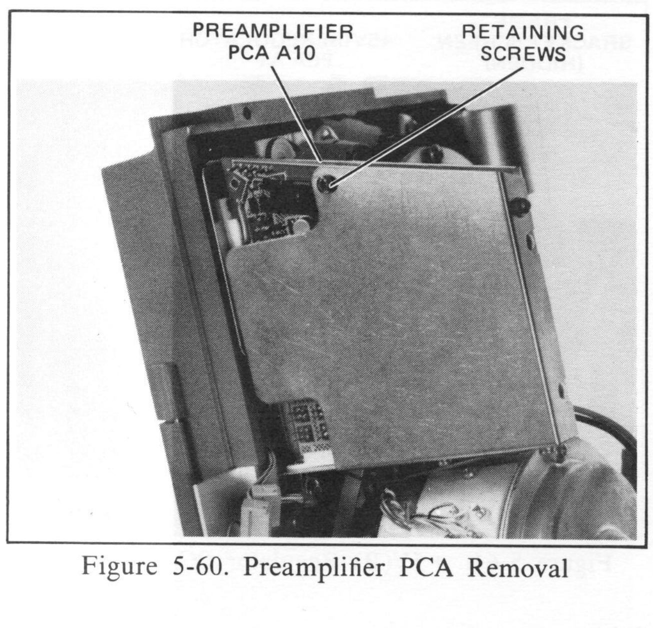


Figure 5-60. Preamplifier PCA Removal

f. Remove the circuit board by sliding from the shield.

NOTE

Troubles can be located in the preamplifier by operating the unit outside of the shield.

g. Reinstall the preamplifier PCA by reversing the removal procedure.

5-154. +5V(B) REGULATOR PCA REMOVAL.

5-155. The +5V(B) Regulator PCA is removed as follows:

a. Disconnect the power cable.

b. Remove the control panel as described in paragraph 5-95.

c. Open the tape transport. Refer to paragraph 5-115.

d. Disconnect the wires from TB1 (see Figure 5-61). Note wire colors for reinstallation.

e. Remove the left side cover as described in paragraph 5-99. Remove bracket screw holding assembly to frame.

f. Remove the screws which retain the regulator PCA (see Figure 5-61).

g. Lift up on the board assembly until it is separated from the bottom connector and remove from the recorder.

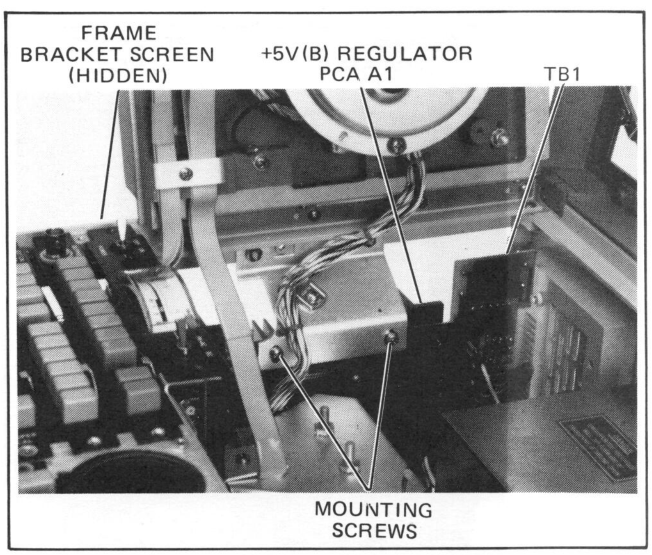


Figure 5-61. +5V(B) Regulator PCA Removal

h. Reinstall by reversing the removal procedure.

5-156. MOTOR DRIVER/+5V(A) REGULATOR PCA REMOVAL.

5-157. This board assembly contains the circuits for the +5 VDC(A) power supply, Capstan Motor Power Drivers, and Reel Motor Current Sources. Remove the assembly using the following procedure:

a. Disconnect the power cable.

b. Remove the control panel as described in paragraph 5-95.

c. Open the tape transport. Refer to paragraph 5-115.

d. Remove the two upper mounting screws as identified in Figure 5-62.

e. Remove the right side cover as described in paragraph 5-99. Remove frame bracket screw.

f. Remove the lower bracket (see Figure 5-62).

g. Lift up the Regulator until it is separated from the bottom connector.

h. Ease the assembly out at the top and free of the recorder.

i. Reinstall by reversing the preceding removal procedure.

5-158. HP-IB ASSEMBLY REMOVAL (OPTION 007 ONLY).

5-159. The HP-IB Assembly is removed using the following procedure:

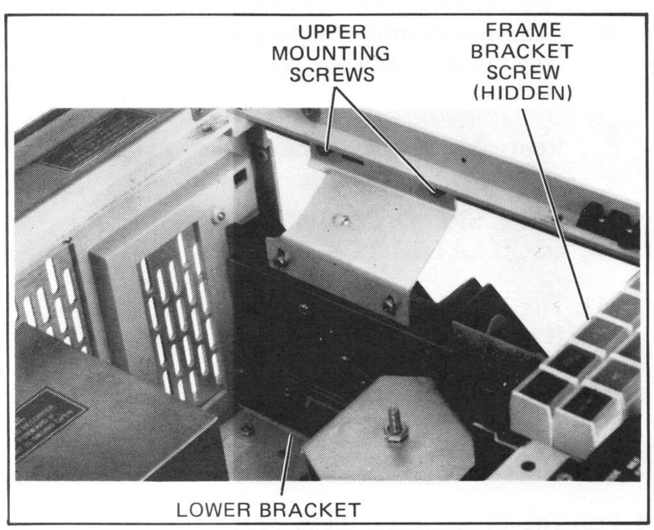


Figure 5-62. Motor Driver/+5V(A) Regulator Removal

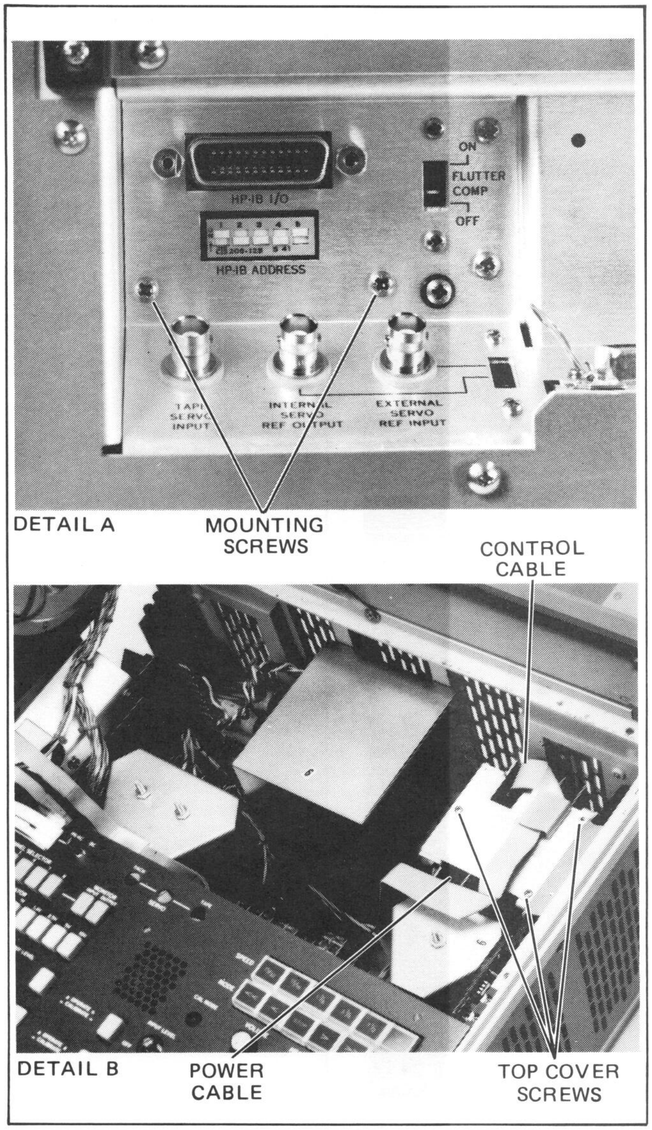


Figure 5-63. HP-IB Assembly Removal

a. Disconnect the power cable and any additional cables from the back of the recorder.

b. Stand recorder upright and open the tape transport (refer to paragraph 5-115).

c. Remove the two screws and lock washers and the two connector nuts from the HP-IB Assembly (see Detail A, Figure 5-63).

d. Remove the control panel as described in paragraph 5-95.

e. Remove the top cover from the HP-IB. The three screws are identified in Detail B, Figure 5-63.

NOTE

Extender boards are provided to assist in HP-IB troubleshooting. The assembly can be moved to a more accessible location at this step of the removal procedure. The control and power cables must be reinstalled for troubleshooting the assembly.

f. Remove the multiconductor flat control cable from the HP-IB Interface PCA (see Detail B, Figure 5-63). The PCA must be pulled from the module to allow connector removal.

g. Unplug the two wire HP-IB power cable from the recorder Interconnect PCA, and remove the HP-IB Assembly from the recorder.

h. To reinstall the assembly, reverse the preceding removal steps.

5-160. TAPE LOOP ADAPTER REMOVAL (OPTION 024 ONLY).

5-161. Use the following procedure to remove the loop adapter.

a. Switch the recorder POWER OFF.

b. Open the Reel Cover. It is held with detents at the bottom and is hinged at the top.

c. Remove the transparent cover from over the right Bin Assembly. The cover can be lifted from the right reel hub since it is held in position with a detent (see Detail A, Figure 5-64).

d. Open the Head Cover by pulling up on the top.

e. Carefully remove the tape loop as illustrated in Detail B, Figure 5-64).

f. Remove the Supply Hub. The hub also is held in position by the tape hub detents and can be simply lifted off (see Detail C, Figure 5-64).

g. Pull off the right turntable from the right tape hub.

h. The Bin Assembly can now be removed. There are three screws on the hub which retain it as illustrated in Detail C, Figure 5-64.

NOTE

This completes the removal of the Tape Loop Adapter. Standard tape reels can be installed for reel to reel recording. If desired, reinstall the Tape Loop Adapter by reversing the preceding removal steps.

Figure 5-64. Tape Loop Adapter Removal

5-162. TROUBLESHOOTING.

5-163. Many recorder problems can be corrected by performing the following tasks:

a. Cleaning the heads, capstan and pinch roller and guides.

b. Degaussing record and reproduce heads.

c. Using a freshly degaussed reel of recommended instrumentation tape.

d. Correct operating procedures.

5-164. Before proceeding with troubleshooting, it is always good practice to check the power supplies. The internal test points and fuses are identified in Figures 5-65 and 5-66. The power supply voltage limits are specified in Table 5-15, but note that they are measured under the following conditions:

a. Control panel removed and tape transport opened to access test points.

b. All PCA's removed from the front of the recorder (which are normally covered by control panel) except the Meter Amplifier PCA (A3).

c. Set Voltage Selector to 120 VAC.

d. Switch recorder power ON.

e. Use a VARIAC to slowly raise line voltage to 120 VAC while monitoring line current (0.4A Max).

f. Check and adjust the +10 supply to +10.500V (between +10.495 and +10.505 VDC) if necessary.

g. Check remaining voltages. Service Sheets 1 through 6 and 24 can assist in isolating a problem.

5-165. If a trouble still exists after performance of the foregoing procedures use the troubleshooting tables that follow. The tables are divided into 12 functional areas:

Table Number	Functional Description
5-16	Power Supplies
5-17	Mode Control
5-18	Tape Transport
5-19	Tape Speed Control
5-20	Servo
5-21	FM Record/Reproduce
5-22	Direct Record/Reproduce
5-23	Voice Channel
5-24	Calibrator
5-25	Meter
5-26	Overlap (Option 070)
5-27	HP-IB (Option 007)

Table 5-15. Power Supply Tolerances (Does not apply to Option 021)

Test Point	Voltage Limits*	
	Minimum	Maximum
+10 (Adjust on A3 Meter Amplifier PCA)	10.495	10.505
-10	-10.47	-10.53
+5A, +5B	5.06	5.18
+16	18.4	20.0
-16	-18.2	-19.8
11	14.9	16.2
-11	-15.1	-16.6
+24	23	25

*Measured with all PCA's except Meter Amplifier PCA removed from front of recorder, Voltage Selector 120V, and 120 Vac applied.

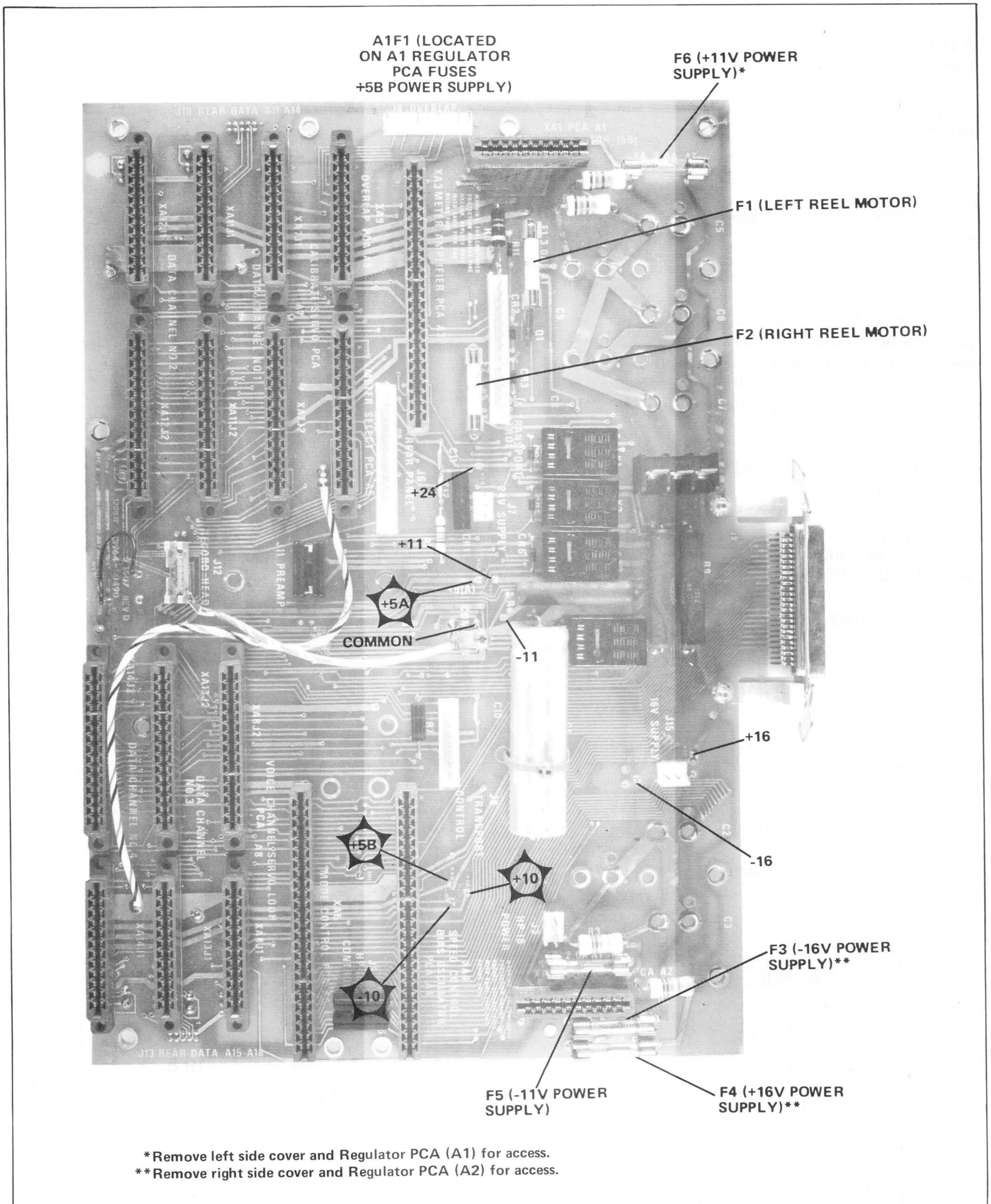


Figure 5-65. Model 3964A Test Point and Fuse Identification
(A1F1 and F3 through F6 added at S/P 1715A)

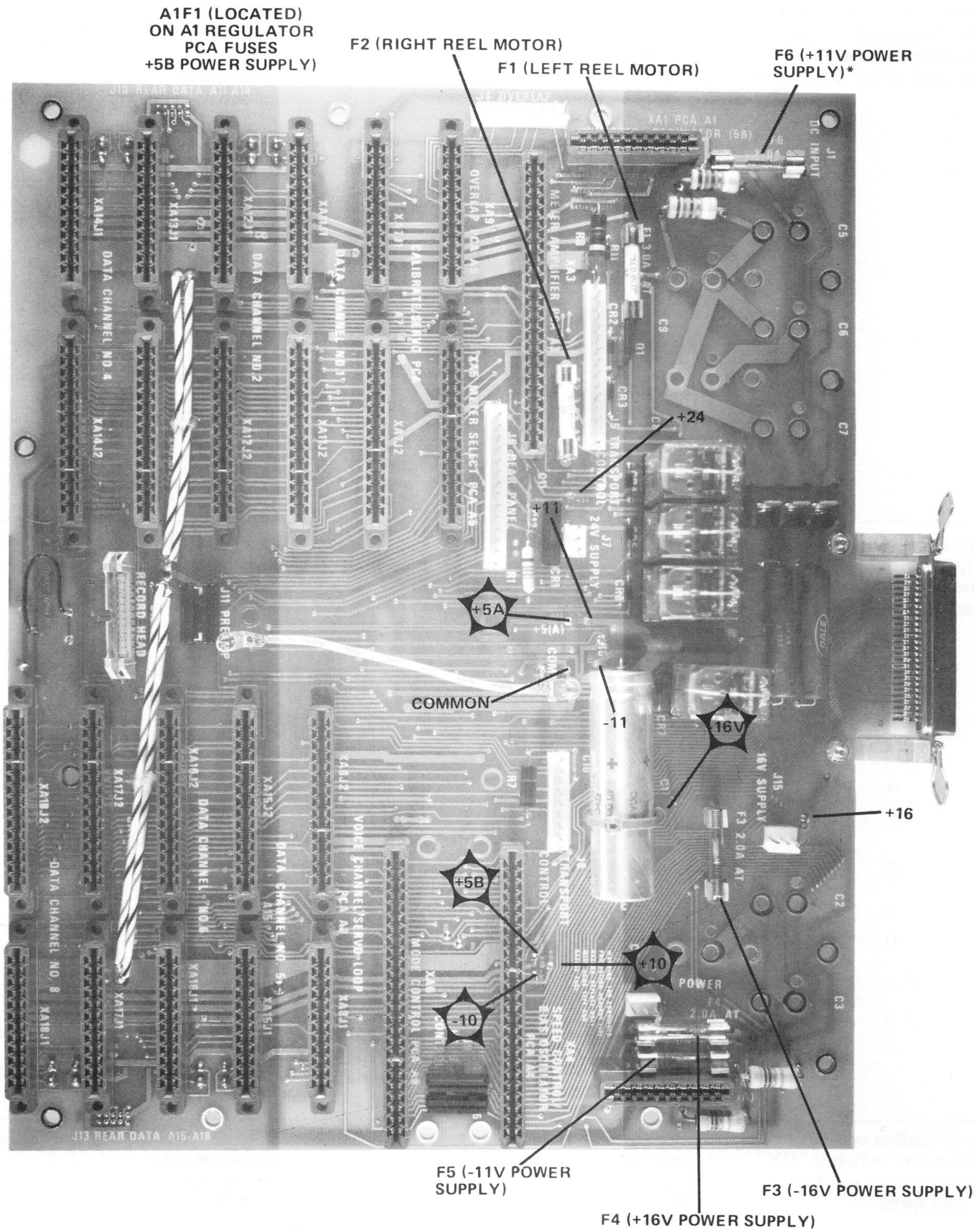


Figure 5-66. Model 3968A Test Point and Fuse Identification
A1F1 and F3 through F6 added at S/P 1715A)

Table 5-16. Power Supplies

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Recorder totally inoperative (no indication of power although power is applied)	Dead AC power source.	Verify AC power.	
	AC line transient tripped circuit breaker or fuse (Line fuse blown on Serial Prefixes before 1710A). A 1.5 AC line fuse (P/N 2110-0043) is recommended for use when 220 or 240 Vac power has been selected.	PUSH to reset circuit breaker (replace AC Line Fuse on Serial Prefixes before 1710A).	Page 3-4 Figure 3-2
	+10.5 Vdc power supply dead.	Check +10 test point on A24 PCA. Troubleshoot and repair.	Page 5-26 Figure 5-15 Service Sheets 5, 6
	+16 Vdc power supply (fused by F4, 2A on S/P 1715A and later recorders).	Check +16 Vdc test point on A24 PCA.	Service Sheets 2, 31 Page 5-26 Figure 5-15
	AC line cord defective.	Replace.	Page 2-9 Figure 2-8
Circuit breaker repeatedly trips after reset (AC line fuse blows on serial prefixes before 1710A)	AC voltage selector (S-2) set to lower line voltage than available.	Check voltage selector S2. Set for line voltage in use.	Page 2-8 Figure 2-6 & Page 1-6 Table 1-1
	Shorted primary circuit.	Remove power and measure resistance from line to neutral of power receptacle with voltage selector on 240V position. Correct reading 5.8 to 6.8 ohms. Also check for a maximum of 0.1 ohm from AC receptacle ground pin to chassis. Isolate defect and repair.	Service Sheet 31
	Secondary circuit failure.	Remove all plug-in PCA's. If circuit breaker continues to trip when power is applied, remove secondary cables from J7, 14 and J15 of Interconnection PCA (A24) to isolate secondary problem. Repair defective assembly.	Page 7-88 Figure 7-47 or Page 7-92 Figure 7-50 Service Sheets 1 thru 6. Service Sheet 31
No indication of power with power switched "ON" except capstan motor runs at high speed	+5 Vdc(B) power supply voltage missing. Test point on Interconnection PCA (A24). Fused by F1 located on the Regulator PCA (A1) located under the left side cover on serial prefix 1715A and later.	Troubleshoot and repair +5 Vdc(B) power supply. Most failures are caused by defective A1U1 or U2.	Service Sheet 2, 3

Table 5-16. Power Supplies (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Power ON indicator does not illuminate but recorder appears to operate normally.	Power ON indicator LED CR8 defective.	Replace CR8 on Meter Amplifier PCA (A3).	Page 5-52 Paragraph 5-146
All FM Data Channels are inoperative, but otherwise recorder operates normally.	+5 Vdc(A) power supply voltage missing. Test point on Interconnection PCA (A24).	Correct power supply problem.	Service Sheets 2, 4
Recorder overheats	Recorder operated outside environment specifications.	Operating limit is +55°C with proper ventilation.	Page 1-6 Table 1-1
	Inadequate recorder ventilation.	Assure air space exists around recorder for proper cooling.	Page 2-1 Paragraph 2-9
	Too high a line voltage for AC voltage selected.	Reposition AC voltage selector (S2) to match available power.	Page 1-6 Table 1-1 Page 2-8 Figure 2-6
Power switch does not remove power from recorder circuits. (Serial prefix 1702A and earlier)	Power switch contacts have shorted.	Replace with new type pushbutton power switch. The part numbers for the switch replacement kits are: Standard 3964A kit P/N 03964-60060 White Panel 8864A kit P/N 03964-60061 Standard 3968A kit P/N 03968-60060 White Panel 8868A kit P/N 03968-60061	
Tape does not move in < (Reverse) mode. It is also noted that > (Forward) mode malfunctions with tape jerking and/or tape looping.	Fuse F5 on the Interconnect PCA (A24) is blown.	Troubleshoot and repair -11V power supply. Replace F5 (2.0A).	Service Sheets 2, 3, 4
Tape does not move in > (Forward) mode.	Fuse F6 on the Interconnect PCA (A24) is blown.	Troubleshoot and repair +11V power supply. Replace F6 (2.0A).	Service Sheets 2, 4

Table 5-17. Mode Control

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Speed and mode select lamps will not illuminate and tape speed not controlled.	+16V and -16V power supply defective. +16V and -16V supplies fused with F4 (2A) and F3 (2A) for later serial prefix 1715A recorders.	Troubleshoot and repair.	Service Sheets 5, 31
	+24 Vdc unregulated power supply failure.	Troubleshoot and repair.	Service Sheets 1, 31
	+5 Vdc(B) power supply voltage missing. Fused by F1 located on the regulator PCA (A1) located under the left side cover on serial prefix 1715A and later.	Troubleshoot and repair +5 Vdc(B) power supply. Most failures are caused by defective A1U1 or U2.	Service Sheets 2, 3
Mode and speed control will not respond to pushbuttons (will not change mode).	Remote control $\overline{\text{INHIBIT}}$ command being held low.	Remove $\overline{\text{INHIBIT}}$.	Page 2-5 Table 2-1
	$\overline{\text{POWER ON PRESET}}$ held low.	Troubleshoot and repair circuit on Meter Select PCA (A5).	Service Sheet 13
	Inhibit Circuit on tape speed control PCA defective (A4U105D and U114A).	Isolate and replace defective component.	Service Sheet 8
Tape will not respond to forward or reverse commands (power supply voltages are OK).	Tape not tensioned properly on tape tension arm roller.	Tension properly.	Page 3-1 Paragraph 3-11
	Rear panel servo reference switch set to external without sufficient reference signal.	Provide proper amplitude and frequency external servo reference signal or switch to internal servo reference for normal operation.	
	Pinch roller is not pressing against the tape with sufficient pressure.	Readjust the pinch roller solenoid.	Page 5-36 Paragraph 5-87
	Pinch roller is very soft.	Replace pinch roller.	Page 5-42 Paragraph 5-113
	Open A24K1, K2 or K3 relay contacts (relays are plugged into sockets on the Interconnection PCA).	Isolate defective relay and replace.	Service Sheets 11, 31
	Defect in Mode Control PCA (A6).	Troubleshoot and repair. Motion latch (A6U9B) and several other components can cause the problem.	
Tape does not move in < (Reverse) mode. It is also noted that > (Forward) mode malfunctions with tape jerking and/or tape looping.	Fuse F5 on the Interconnect PCA (A24) is blown.	Troubleshoot and repair -11V power supply. Replace F5 (2.0A).	Service Sheets 2, 3, 4

Table 5-17. Mode Control (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Tape does not move in > (Forward) mode.	Fuse F6 on the Interconnect PCA (A24) is blown.	Troubleshoot and repair +11V power supply. Replace F6 (2.0A).	Service Sheets 2, 4
Mode control inoperative (no lights) and tape will not move.	Loss of tape tension.	Tension tape.	Page 3-1 Paragraph 3-11
	Defective end of tape circuit.	Troubleshoot end of tape microswitches and end of tape delay circuit on Mode Control PCA (A6).	Service Sheets 14, 31
Mode control buttons do not illuminate but modes operate properly.	Defective current limiter.	Troubleshoot Mode Control A6Q15.	Service Sheet 14
	Mode Control PCA (A6) lamp control gate or lamp driver defective.	Troubleshoot and replace.	Service Sheet 14
	Bulbs burned out.	Replace bulb in Mode Control Button.	
No record function.	Mode Control PCA (A6) record control or record latch circuit failure.	Troubleshoot and repair.	Service Sheet 14
	A24K4 Record Relay.	Replace.	Page 7-88 Figure 7-47 or Page 7-92 Figure 7-50
Panel lamps flash on and off and dim when "RECORD" is pushed.	Direct or FM Record/ Reproduce PCA K1 record	Isolate defective relay and replace.	Service Sheets 22, 25, 26, 27
Mode lights very dim.	K1 Record Relay in any data PCA shorted.	Isolate by removing data PCA's and replace defective relay.	Service Sheet 25 or 27
	Regulated +24V power supply voltage low (tolerance +24 ±1V).	Troubleshoot and repair.	Service Sheet 1
	A6Q15 Mode Control current limiter.	Troubleshoot and repair.	Service Sheet 14
Tape moves forward when reverse is selected and reverse when forward is selected.	Tape threaded incorrectly.	Thread properly.	Refer to diagram on head cover.
	$\overline{\text{Forward Selected}}$ and $\overline{\text{Reverse Selected}}$ commands in error from Mode Control PCA (A6).	Troubleshoot and repair.	Service Sheets 9 and 10

Table 5-17. Mode Control (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Fast forward and/or fast reverse modes inoperative.	A reel motor fuse opened. F1 and F2 are the reel motor fuses on the interconnection PCA (A24). Also check F6.	Replace fuse and repair. A reel motor with incorrectly shimmed or warped armature can cause the fuse to open.	Service Sheet 12 Page 5-45 Paragraph 5-122
	Mode Control PCA (A6) defective.	Troubleshoot and repair. Fast/slow control gates (A6U6C, U6D) and fast/slow latch (A6U14A) are suspect.	Service Sheet 14
	Defective relay. Reel motor control relays (A24K1, K2 and K3) are located on the Interconnection PCA (A24).	Isolate and replace defective relay.	Service Sheet 12

Table 5-18. Tape Transport

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Tape stops without apparent reason when recording or reproducing tape. Tach and mode lamps still illuminated.	Pinch roller not applying sufficient pressure to tape.	Adjust pinch roller solenoid – the pinch roller roll pin clearance is probably insufficient.	Page 5-36 Paragraph 5-87
Tape movement stops without apparent reason when recording or reproducing tape. Mode lamps still illuminated but not TACH.	Rear panel switch in external servo ref. input position, but without correct external servo ref. signal applied to rear BNC. Amplitude should be more than +2V peak and frequency between 540 Hz and 30 kHz.	Apply specified external servo ref. signal or switch to Internal Servo Reference.	Page 3-4 Figure 3-2
	Calibrator/Servo PCA (A7) Reference Frequency Oscillator (Q201, Q202). Divide by 2 (U6B, U21A) programmed divider U23), or 15/32 ips speed reference frequency selector defective.	Troubleshoot and repair.	Service Sheets 15, 16
	Voice channel/servo PCA (A8) INT/EXT reference frequency selector (U105A, B, C) pulse shaper (U113) power amp control (Q102), power amplifier (U103), or output limiters (Q105, Q106) defective.	Troubleshoot and repair.	Service Sheets 15, 16
Tape will not move and tape speed light dim.	AC voltage selector (S2) switch set for higher than available power.	Reposition (S2) for correct line voltage.	Page 2-8 Figure 2-6

Table 5-18. Tape Transport (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Excessive flutter (causes noise on FM channel outputs).	Dirty tape path.	Clean.	Page 3-24 Paragraph 3-96
	Defective or low quality tape.	Replace with new reel of recommended tape.	Page 3-1 Paragraph 3-7
	Warped tape reel.	Replace.	
	Pinch roller not adjusted properly.	Adjust.	Page 5-36 Paragraph 5-87
	Defective dampers.	Replace. A light oil film is normal on dampers but replacement is recommended if they leak oil.	Page 5-50 Paragraph 5-136
	Pinch roller bearing worn.	Replace.	Page 5-42 Figure 5-113
	Capstan motor defective.	Replace.	Page 5-44 Figure 5-119
	Heavy brush deposit in reel motors.	Clean or replace.	Page 5-45 Paragraph 5-122
Tape broken or stretched.	Storage or operation outside of the recommended temperature range (10°C to 40°C).	Replace.	Page 3-1 Paragraph 3-9
	Poor quality audio recording tape.	Replace with recommended tape.	Page 3-1 Paragraph 3-7
	Tape transport control problem (tension is not maintained on tape or tape is stressed with very high tension during any mode or when changing modes).	Check paper operation of brakes, reel motors, capstan motor and pinch roller solenoid under various control modes.	Page 5-4 Paragraph 5-31 Service Sheets 5, 9, 10, 11, 12, 14, 15, 16
Edge of recording tape is damaged.	Careless storage or handling.	Store tapes in boxes on edge within a temperature range of 10°C to 40°C and handle carefully. Replace tape.	Page 3-1 Paragraph 3-9
	Warped tape reel.	Replace tape reel and tape.	
	Bent damper arm.	Replace damper and tape.	Page 5-50 Paragraph 5-136
Recording tape rewinds unevenly on reel. (It is normal for the recording tape to pack unevenly on the tape reel – it causes no tape damage and has no effect on the quality of recordings).			

Table 5-18. Tape Transport (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Oil inside recorder. Tension arms bounce excessively. A light oil film on Dampers is normal.	Dampers leaking.	Replace damper assembly.	Page 5-50 Paragraph 5-136
Start times out of spec. (See Table 1-1 on Page 1-3)	Pinch roller.	Adjust.	Page 5-36 Paragraph 5-87
	Dragging brakes.	Adjust brakes.	Page 5-36 Paragraph 5-89
	Servo circuits providing insufficient drive to capstan motor.	Troubleshoot and repair.	Service Sheets 15, 16
Stop times out of spec.	Brakes misadjusted.	Adjust.	Page 5-36 Paragraph 5-89
	Brakes dirty.	Clean brakes.	Page 5-1 Paragraph 5-13
	Brake solenoid or brake linkage binding.	Clean and adjust as required for free operation.	Page 5-1 Paragraph 5-15 Page 5-48 Paragraph 5-126
Tape movement stops for no apparent reason with mode buttons not illuminated.	End of tape (EOT) switches causing false end of tape signal.	Adjust.	Page 5-38 Paragraph 5-91
	Dampers.	Replace.	Page 5-50 Paragraph 5-136
	End of tape delay time less less than one second.	Troubleshoot and repair end of tape delay circuit on mode control PCA (A6).	Service Sheet 14
	Motor armature incorrectly shimmed.	Remove cover from motor and add or remove shims as necessary.	Page 5-45 Paragraph 5-122
	Reel motor armature warped.	Replace.	Page 5-45 Paragraph 5-122
Reel motor makes "scraping" noises (recorder may "throw tape loops" and stop before the end of tape).	Motor armature incorrectly shimmed.	Remove cover from motor and add or remove shims as necessary.	Page 5-45 Paragraph 5-122
	Reel motor armature warped.	Replace.	Page 5-45 Paragraph 5-122

Table 5-18. Tape Transport (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Counter inoperative.	Drive belt off pulley or broken.	Reinstall on pulley or order new belt.	
	Counter jammed.	Replace counter.	Page 5-51 Paragraph 5-138
	Counter shaft binding on casting.	Loosen counter mounting screws and reposition for proper clearance.	Page 5-51 Paragraph 5-138
Reel motors do not stop at end of tape.	End of tape microswitches improperly adjusted.	Readjust.	Page 5-38 Paragraph 5-91
	Spring on tape damper is too weak.	Replace spring.	Page 5-50 Paragraph 5-136
	Mode Control PCA (A6).	Troubleshoot and repair end of tape circuit.	Service Sheets 9, 10
No reverse play and excessive tape tension in forward play.	-11 VDC Supply DEAD. -11 VDC power supply fused with F5 (2A) on serial prefix 1715A and later recorders.	Troubleshoot and repair.	Service Sheets 2, 31
New capstan assembly does not have detent to secure head cover closed.	Head cover mechanism has been redesigned with reliable, spring activated hinges.	Install new type head cover mechanism (refer to Service Note P-03968-60200/60210/62200/62210).	Figure 6-2 Table 6-4 items 106, 108, 109 & cover pins P/N 03964-20670 (2 ea) required.
Fast forward and fast reverse tape speeds very slow (typical rewind time of 1800 foot reel is 100 sec. and 2300 foot reel is 145 sec. but due to manufacturing tolerances it is not unusual for rewind times to be 40% slower than typical).	Brake bands dragging.	Adjust brakes for clearance between bands and reel hubs when brakes are released.	Page 5-3 Paragraphs 5-36, 5-89
	Reel motor rotor scraping.	Reshim and/or replace.	Page 5-45 Paragraph 5-122
	Line voltage lower than recommended range of AC power switch setting. (Tolerance ±10%.)	Change power switch setting to match available line voltage.	Page 2-8 Figure 2-6
	Pinch roller clearance insufficient.	Adjust.	Page 5-36 Paragraph 5-87
	Reel revolution counter worn.	Replace.	Page 5-51 Paragraph 5-138

Table 5-18. Tape Transport (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
No indicator lights and capstan runs uncontrolled.	-10.5 VDC power supply dead.	Troubleshoot and repair.	Service Sheet 6
	+16 & -16 VDC power supply fuses blown (A24F4 & F3)	Troubleshoot and repair.	Service Sheets 5, 31
	+5V (B) power supply dead.	Troubleshoot and repair. Check A1F1 on Regulator PCA.	Service Sheet 2
Tape loops on floor.	Reel brakes misadjusted.	Adjust.	Page 5-36 Paragraph 5-89
	Defective reel motor or associated wiring.	Troubleshoot and repair.	Page 5-45 Paragraph 5-122 Service Sheets 11 & 12
	Pitted relay contacts A24K1, 2, 3 or 4.	Replace relay on Interconnection PCA (A24).	Page 7-92 Figure 7-50 or Page 7-88 Figure 7-47
	A reel motor fuse opened. F1 and F2 are the reel motor fuses on the interconnection PCA (A24).	Replace fuse and repair. A reel motor with incorrectly shimmed or warped armature can cause the fuse to open.	Service Sheet 12 Page 5-45 Paragraph 5-122
Tape tangled up around pinch roller and capstan.	Heads, capstan and guides "dirty".	Instruct operator to clean recorder heads, capstan and guides before each recording.	Page 3-24 Paragraph 3-96
	Improper tape splice.	Repair tape using quality splicing kit.	
	Take-up reel is warped and rubs on transport.	Replace reel.	
	High temperature and humidity have caused tape to stick to capstan surface.	Use recommended 3M888 recording tape and/or record in a more favorable environment.	Page 3-1 Paragraph 3-7 thru 3-10
	Reel brakes are misadjusted and dragging.	Readjust brakes.	Page 5-36 Paragraph 5-89
	Reel motor armature scrapes.	Reshim the motor armature for correct clearance.	Page 5-45 Paragraph 5-122

Table 5-18. Tape Transport (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Tape does not move in FORWARD or REVERSE PLAY. (Power supply voltages OK)	Tape is not tensioned against tape rollers properly.	Instruct operator in proper tape loading.	Page 3-1 Paragraph 3-11
	Rear panel servo reference switch set to external without sufficient reference signal.	Provide proper amplitude and frequency external servo reference signal or switch to Internal Servo Reference for normal operation.	
	Pinch roller is not pressing against the tape with sufficient pressure.	Readjust the pinch roller solenoid.	Page 5-36 Paragraph 5-87
	Pinch roller is very soft.	Replace pinch roller.	Page 5-42 Paragraph 5-113
	Open A24K1, K2 or K3 relay CONTACTS. (Relays are plugged into sockets on the Interconnection PCA.)	Isolate defective relay and replace.	Service Sheets 11, 31
Time Base Error out of specification. (See specifications on page 1-3, Table 1-1 and Performance Test on page 5-13, Paragraph 5-46.)	Tape slipping because of dirty capstan.	Clean capstan and pinch roller.	Page 3-24 Paragraph 3-96
	Pinch roller improperly adjusted.	Adjust.	Page 5-36 Paragraph 5-87
	Servo Electronics defect.	Troubleshoot and repair.	Service Sheets 15 and 16
	Capstan Motor defective.	Replace.	Page 5-44 Paragraph 5-119
Tape speed out of ±0.2% accuracy specification.	Dirty capstan.	Clean.	Page 3-24 Paragraph 3-96
	Pinch roller slipping.	Adjust solenoid.	Page 5-36 Paragraph 5-87
	Brake dragging.	Adjust.	Page 5-36 Paragraph 5-89
	Dragging reel (warped).	Replace reel.	
	Internal Reference Oscillator out of spec. (Performance test, page 5-11, paragraph 5-41.)	Troubleshoot and repair.	Service Sheets 15, 16

Table 5-19. Speed Control

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Recorder operates properly but button does not "light".	Bulb burned out.	Replace bulb.	
	Poor solder joint on switch.	Resolder.	
	Speed Lamp driver defective. (A6U106)	Replace.	Service Sheet 8
Pushbuttons come off.	Buttons not seated properly.	Press cap fully on and pinch bottom of button in until it "seats" into position.	
Front panel speed pushbuttons have no control over speed.	If capstan speed runs away, the servo has broken lock.	Refer to Servo Troubleshooting table. Most likely the problem is on the A7 or A8 PCA or Capstan Motor.	Servo Troubleshooting Table
	$\overline{\text{Remote Inhibit}}$ signal is being held low by external remote control circuit.	Remove $\overline{\text{Remote Inhibit}}$ signal.	Page 2-4 Figure 2-4
	Tape Speed Control PCA (A4) Inhibit circuit (U105D, U114A) or other logic circuits defective.	Troubleshoot and replace defective component.	Service Sheet 8
	If only 3-3/4 IPS speed button illuminates, the Power Defector (A4U114B or Q102) is probably defective.		
Speed pushbutton lamps illuminate properly but the tape speed is incorrect on one speed.	Speed A Inverter (A4U104, U105) providing incorrect speed A command.	Troubleshoot and repair.	Service Sheets 7, 8
	Programmed divider (A7U23, U21A) on Calibrator/Servo PCA (A7) defective.	Troubleshoot and repair.	Service Sheets 15, 16
Speed pushbutton lamps illuminate properly and tape speeds are correct but all data channels do not meet band pass or signal to noise specifications on the same tape speeds.	Speed B Inverter (A4U107, U108, U109) providing incorrect speed B commands.	Troubleshoot and repair.	Service Sheets 7, 8

Table 5-20. Servo

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Tape speed is uncontrolled in forward or reverse modes.	Servo is "breaking lock".	Voice/Servo PCA (A8) or Calibrate/Servo PCA (A7) defective or have poor contact in connector. Troubleshoot and repair.	Service Sheets 15, 16
		Servo phase balance adjustment required.	Page 5-29 Paragraph 5-76
		Capstan assembly may be defective. Replace if the waveform on TP1 of the Voice Channel/Servo PCA has an amplitude of less than 500 mV pk/pk or if the dc level at TP1 falls outside the -4 to -6 Vdc range or if severely clipped. It should look like a sine wave.	Page 5-44 Paragraph 5-119
		Verify that the ±16V barrier block (J14) lug screws are tight.	Page 7-92 or Page 7-88
	Pinch roller not applying sufficient pressure to tape.	Adjust pinch roller solenoid.	Page 5-36 Paragraph 5-87
Tape will not move in Forward or Reverse modes.	Internal/External Servo Reference Select Switch in EXT position without a proper signal. Required signal is 1V pk/pk.	Increase the amplitude of the External Servo Reference or use Internal Servo Reference.	Page 3-2 Figure 3-2
	Reel brakes not releasing.	Troubleshoot and repair.	Service Sheet 10
	CAL/SERVO PCA (A7) Internal Reference Oscillator.	Verify output by checking Internal Servo Reference Output on rear panel. Troubleshoot and repair.	Service Sheets 15, 16 Page 5-11 Paragraph 5-41
	Voice Channel/Servo PCA (A8). INT/EXT Reference Frequency Selector (U105A, B, C), Pulse Shaper (U113), Power Amp Control (Q102), Power Amp (U103) or Output Limiters (Q105, Q106) defective.	Troubleshoot and repair.	Service Sheets 15, 16

Table 5-20. Servo (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
When reproducing in TAPE SERVO mode, the TACH indicator indicates TACH Servo lock or blinks rather than the desired TAPE SERVO lock.	Improper procedure used when INTERNAL SERVO REF OUTPUT signal was recorded or OUTPUT level too low when reproducing.	Degauss tape and record using recommended procedure.	Page 3-12 Paragraph 3-35
	Signal dropouts cause automatic SERVO mode changes to "TACH".	Clean recorder heads, capstan and pinch roller thoroughly, if drop outs continue replace recording tape.	Page 3-24 Paragraph 3-96 Page 3-1 Paragraph 3-7
	Defect in tape servo electronics.	Troubleshoot and repair. Likely circuits are Filter and Tape Frequency Shaper (A8U102), Tape Frequency Level Detector (A7U13, U8) or Tape Mode Enable (A7U22A, U19C).	Service Sheets 15, 16
	Calibrator/Servo PCA (A7) Tape Frequency Level Detector (U13, U8) original configuration. (Model 3964A Serial Prefix 1620A and earlier. Model 3968A Serial Prefix 1622 and earlier.)	Replace A7R211 with 8.25K P/N 0757-0441	Service Sheet 16
Servo "TACH" light blinks. (Servo switch in TACH position.)	EXTERNAL SERVO REF INPUT signal amplitude less than 2V pk/pk.	Increase the amplitude of this externally applied signal or switch to INTERNAL SERVO REFERENCE.	Page 3-4 Figure 3-2
	Servo phase balance adjustment required.	Adjust.	Page 5-29 Paragraph 5-76
	Voice Channel/Servo PCA (A8) or calibrate/servo PCA (A7) defective.	Troubleshoot and repair.	Service Sheets 15, 16
	Defective capstan assembly.	Replace with a rebuilt capstan if: The waveform at TP1 of the Voice Channel/Servo PCA (A8) has an amplitude of less than 600 mV pk/pk, if the DC level at TP1 falls outside the -4 to -6 Vdc range or the waveform is severely clipped.	Page 5-44 Paragraph 5-119

Table 5-21. FM Record/Reproduce

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
No output signals from FM DATA PCA in forward, reverse or E to E Mode.	FM Record/Reproduce PCA in CALIBRATE Mode or the OUTPUT LEVEL turned OFF.	Check operating procedures.	Page 3-5 Paragraph 3-13
	+5V (A) supply DEAD.	Troubleshoot and repair power supply is located on Regulator PCA (A2).	Service Sheet 4
	Defect in FM Record/ Reproduce PCA.	Troubleshoot and repair.	Service Sheets 22, 25
FM Data PCA operates OK in E to E Mode but there is no output in forward or reverse modes.	Tape threaded incorrectly.	Thread recording tape with oxide side against heads.	Page 3-1 Paragraph 3-11
	Bias Oscillator failure when FM Data PCA's are jumped for bias operation.	Troubleshoot and repair the bias oscillator on the Speed PCA (A4).	Service Sheet 8
	Preamplifier PCA failure.	Repair defective pre-amplifier. Defective channel usually has more than 1.8 VDC or oscillation on pre-amplifier test point.	Service Sheets 22, 23, 24
	FM Record/Reproduce PCA failure.	Isolate problem and repair. Record Head Drivers (Q5, 6, 7, 8) can cause the problem.	
FM Reproduce noisy. (Does not meet Signal to Noise Ratio Specification. Refer to Page 5-19, paragraph 5-55 for performance verification.)	Worn, defective, or poor quality recording tape.	Replace with new reel of recommended recording tape.	Page 3-1 Paragraph 3-7
	Tape path dirty.	Clean.	Page 3-24 Paragraph 3-96
	Flutter out of specification.	Troubleshoot and repair.	Refer to Tape Transport Troubleshooting Table
	FM Record/Reproduce PCA requires calibration.	Adjust.	Page 5-29 Paragraph 5-77 thru Page 5-34 Paragraph 5-83
	Defective FM Record/ Reproduce PCA (usually OK if signal to noise is all right in E to E).	Isolate problem between Record and Reproduce section by interchanging PCA's. Isolate defect and repair.	Service Sheets 22, 25

Table 5-21. FM Record/Reproduce (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
FM Reproduce noisy. (Does not meet Signal to Noise Ratio Specification. Refer to Page 5-19, paragraph 5-55 for performance verification.) (Continued)	Preamplifier PCA (A10).	Defective channel usually has more than 1.8 VDC or oscillation on pre-amplifier test point. Troubleshoot and repair.	Service Sheets 22, 23, 24
	Bias oscillator frequency below 300 kHz.	Troubleshoot and repair bias oscillator on tape speed PCA (A4).	Service Sheet 8
	Early Model 3968A FM Record/Reproduce PCA's (Serial Prefix 1602A and earlier) have not been updated as described in Service Note 3968A-1/8868A-1A.	Remove resistors R35 (51.1K) and R36 (215K) from each FM PCA.	Refer to Service Note or Preliminary Manual (May '76 or Dec. '76) for resistor location
Output distorted (Distortion performance test is on Page 5-16, paragraph 5-53).	Input signal overdriving FM Record/Reproduce PCA.	Set up INPUT LEVEL properly.	Page 3-6 Paragraph 3-16
	Band width limitation of tape speed being used.	Increase tape speed for adequate band width.	Page 1-4 Table 1-1
	Input unipolar selector jumper set improperly.	Reposition jumper.	Page 3-15 Paragraph 3-47
	Recording tape not degaussed.	Use only degaussed tape for recording.	Page 3-26 Paragraph 3-100
	Recorder heads magnetized.	Degauss recorder heads.	Page 3-25 Paragraph 3-98
	Calibration needed.	Adjust.	Page 5-29 Paragraph 5-77 thru Page 5-34 Paragraph 5-83
	Defect in FM Record/Reproduce PCA.	Troubleshoot and repair. Low pass filters (U10, U11) can fail causing severe offset.	Service Sheets 22, 25
FM Output Amplitude falls off more than 1.0 dB at upper band edge. (Passband specifications listed on Page 1-4, Table 1-1, performance check of FM Data Channel is on Page 5-5 thru 5-7, paragraph 5-32).	Amplitude/phase selector in Ø position.	Reposition jumper in amplitude position.	Page 3-7 Figure 3-5
	Defect in low pass filters (U10, U11) or output amplifier (U12). If some speeds check OK, there is probably a leaky F.E.T. switch (Q26 thru Q45).	Troubleshoot and repair.	Service Sheets 22, 25

Table 5-21. FM Record/Reproduce (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
FM flutter compensation inoperative. (Model 3964A Channel 2 or Model 3968A Channel 5 is used only for flutter compensation when FLUTTER comp switch is "ON").	FM Record/Reproduce PCA not installed in flutter comp channel.	Install FM PCA.	Page 5-51 Paragraph 5-142
	INPUT LEVEL control turned "ON" with an input signal applied to flutter compensation channel.	Turn INPUT LEVEL "OFF" to prevent a flutter compensation channel INPUT signal from modulating all FM channel outputs.	Page 3-11 Paragraph 3-33
	Flutter comp FM Record/ Reproduce PCA flutter buffer amp (U13) defective.	Replace.	Service Sheets 22, 25
Large DC offset on FM output with 0 VDC input.	Unipolar output selector set to (+) or (-).	Reset jumper to normal (C) to (0) position.	Page 3-5 Paragraph 3-14
	FM PCA needs calibration.	Adjust.	Page 5-29 Paragraph 5-77 thru Page 5-32 Paragraph 5-82
	Failure on FM Record/ Reproduce PCA. Likely circuits are the low pass filters (U10, U11), Output Amplifier (U12), Input Buffer Amplifier (U1) and Level Shifting Amplifier (U2).	Troubleshoot and replace defective component.	Service Sheets 22, 25
FM Record/Reproduce PCA does not meet linearity specification. (±0.3% PK to PK output for best straight line through zero at ±40% deviation for all P/N 03964-60505 PCA's. The older FM PCA's of P/N 03964-60500 and P/N 03968-60500 should be checked to a ±1.0% specification).	Incorrect test set up or procedure used.	Recheck using recommended procedure.	Page 5-15 Paragraph 5-50
	FM PCA needs calibration.	Adjust.	Page 5-29 Paragraph 5-77 thru Page 5-32 Paragraph 5-82
	FM Record/Reproduce PCA defective. The integrated circuit voltage controlled oscillators (U3, U9 P/N 03968-80166) are likely to cause linearity problems on P/N 03964-60500 and P/N 03968-60500 FM PCA's.	Troubleshoot and repair.	Service Sheets 22, 25

Table 5-21. FM Record/Reproduce (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
FM Record/Reproduce PCA output voltage drifts with temperature. (Specification is ±0.1% (max) for full scale output per °C.)	FM Record/Reproduce PCA defective. The integrated circuit voltage controlled oscillators (U3, U9 P/N 03968-80166) are likely to cause drift problems on P/N 03964-60500 and P/N 03968-60500 FM PCA's. A record section problem can be identified by checking frequency drift at test jack J1 with a calibration signal of +DC 0V applied.	Troubleshoot and repair.	Service Sheets 22, 25
	±10.5 Vdc Power Supply drifting.	Troubleshoot and repair.	Service Sheets 5, 6
INPUT LEVEL adjust will not come up to 0 dB level with meter in PK-AC mode (±40% carrier deviation).	Operate/Calibrate switch is incorrectly set.	Switch to operate mode when using INPUT BNC on Data Channel	Page 3-6 Paragraph 3-16
	Input signal too low in amplitude.	Increase the amplitude of the Input Signal.	Page 3-6 Paragraph 3-16
	Metered Channel Select PCA Switches corroded or dirty.	Clean the switch contacts or replace switch.	Page 5-52 Paragraph 5-144
	Input Buffer Amplifier circuit defect.	Troubleshoot and repair.	Service Sheets 22, 25
	METER AMPLIFIER not properly calibrated.	Adjust.	Page 5-26 Paragraph 5-72
	Meter Amplifier defect.	Troubleshoot and repair.	Service Sheet 6
Unknown signal beating with FM outputs (a small amount of FM carrier will always be present on FM outputs but should not prevent amplifier from meeting signal to noise specifications).	Signal being applied to FM flutter compensation channel (Model 3964A channel 2 or 3968A channel 5) with Flutter Compensation switch "ON".	Switch "OFF" input level of flutter compensation channel or switch "OFF" flutter compensation.	Page 3-11 Paragraph 3-33
	Defect in FM Record/ Reproduce PCA.	Troubleshoot and repair. If frequency matches FM carrier, problem may be in one of the low pass filter sections (U10, U11).	Service Sheets 22, 25
OUTPUT LEVEL TOO LOW (should be adjustable from 1 to 5V pk to pk when recording was made at 40% maximum carrier deviation).	Recording was made with too low an INPUT LEVEL.	Rerecord with a higher INPUT LEVEL.	Page 3-6 Paragraph 3-16
	Recorded signal frequency exceeded specified band width at tape speed.	Record at higher tape speed.	Page 1-4 Table 1-1
	Defect in reproduce amplifier. Check Output Amplifier (U12, Q46, Q47, and low pass filters (U10, U11).	Troubleshoot and repair.	Service Sheets 22, 25

Table 5-21. FM Record/Reproduce (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
OUTPUT LEVEL too low (should be adjustable from 1 to 5V pk to pk when recording was made at 40% maximum carrier deviation). (Continued)	FM Record/Reproduce PCA requires calibration.	Adjust.	Page 5-29 Paragraph 5-77 thru Page 5-34 Paragraph 5-83
	Meter requires calibration.	Adjust.	Page 5-26 Paragraph 5-72
	Meter failure.	Troubleshoot and repair.	Page 5-52 Paragraph 5-144 and Service Sheet 6

Table 5-22. Direct Record/Reproduce

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Direct Data Channels and Voice will not record. FM Channels operate OK.	Bias Oscillator inoperative.	Troubleshoot and repair Bias Oscillator on the A4 Speed/Bias PCA.	Service Sheet 8
Direct Record and or Reproduce Inoperative or intermittent.	Very dirty Record/Reproduce heads.	Clean.	Page 3-24 Paragraph 3-96
	Defective recording tape.	Replace with recommended tape.	Page 3-1 Paragraph 3-7
	PCA edge connectors and mating socket are not making proper contact.	Clean connectors.	
	Preamplifier PCA (A10).	Troubleshoot and repair.	Service Sheets 23, 24, 25
	Direct Record/Reproduce PCA defective.	Isolate problem between record and reproduce section by interchanging PCA's. Troubleshoot and repair.	Service Sheets 26, 27
	Tape threaded incorrectly.	Thread recording tape with oxide side against threads.	Service Sheets 23, 24, 25
Direct Reproduce noisy. (Does not meet signal to noise ratio specification. Refer to Page 5-22, paragraph 5-61 for performance verification.)	Tape path dirty.	Clean.	Page 3-24 Paragraph 3-96
	Worn, defective or poor quality recording tape.	Replace with new reel of recommended recording tape.	Page 3-1 Paragraph 3-7
	Interhead shield not installed between record and reproduce heads.	Install.	

Table 5-22. Direct Record/Reproduce (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Direct Reproduce noisy. (Does not meet signal to noise ratio specification. Refer to Page 5-22, paragraph 5-61 for performance verification). (continued)	Direct Record/Reproduce PCA requires calibration.	Adjust.	Page 5-32 Paragraph 5-83
	Preamplifier PCA (A10).	Defective channel usually has more than 1.8 VDC or oscillation on preamplifier test point. Troubleshoot and repair.	Service Sheets 23, 24, 26, 27
	Meter Amplifier not properly calibrated.	Adjust.	Page 5-26 Paragraph 5-72
	Defective Direct Record/ Reproduce PCA.	Isolate problem between record and reproduce section by interchanging PCA's. Troubleshoot to component and repair. Integrated circuits are most likely to fail-look for oscillation.	Service Sheets 26, 27
	Worn record or reproduce head.	Replace.	Page 5-41 Paragraph 5-109
Output signals distorted.	High frequency components in input signal beyond recorder band pass.	Increase tape speed.	Page 1-5 Table 1-1
	Equalizer jumpers not properly set.	Check jumpers and reposition as required.	Page 3-9 Paragraph 3-21
	Direct Record/Reproduce not calibrated for recording tape.	Calibrate.	Page 5-32 Paragraph 5-83
	Meter Amplifier not properly calibrated.	Adjust.	Page 5-26 Paragraph 5-72
	Recorder Heads magnetized causing second harmonic distortion.	Degauss recorder heads.	Page 3-25 Paragraph 3-98
	Failure in Data PCA.	Troubleshoot and repair. The integrated circuits are most likely to fail. If distortion only appears on certain tape speeds the problem may be in the F.E.T. switches (Q201 thru Q220).	Service Sheets 26, 27
	Recorder Heads worn or defective.	Replace.	Page 5-41 Paragraph 5-109

Table 5-22. Direct Record/Reproduce (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Signal DROPS OUT on recorder outputs (drop outs are temporary reductions of signal amplitude of greater than 6 dB).	Dirty recorder heads, pinch roller, capstan and guides.	Clean tape path.	Page 3-24 Paragraph 3-96
	Poor quality or worn recording tape.	Use recommended tape.	Page 3-1 Paragraph 3-7
	Tape damaged due to operating or environmental factors.	Replace damaged tape.	Page 3-1 Paragraph 3-9
	Reel motors providing insufficient tape tension.	Troubleshoot and repair. The reel motors or the motor drivers/regulator PCA (A2) may be defective.	Page 5-45 Paragraph 5-122 Service Sheets 4, 11
Crosstalk (signal recorded on one channel appears on other channels also).	Interhead shield not in place.	Install interhead shield.	Page 3-25 Figure 3-15 Detail A
	Bias jumpers on FM channels not set properly.	Set for bias recording (C to B).	Page 3-7 Figure 3-5
	Worn or defective record head.	Replace.	Page 5-41 Paragraph 5-109
Output level too low. (Should be adjustable from 0.5 to 5V PK to PK when recording was made at 0 dB input level).	Recording tape has insufficient output.	Replace with recommended recording tape.	Page 3-1 Paragraph 3-7
	Equalizer jumpers not properly set.	Check jumpers and reposition as required.	Page 3-9 Paragraph 3-21
	Direct Record/Reproduce PCA requires calibration for recording tape being used.	Adjust.	Page 5-32 Paragraph 5-83
	Record and reproduce heads dirty.	Clean.	Page 3-24 Paragraph 3-96
	Input signal exceeds specified band width (Page 1-5, Table 1-1).	Increase tape speed.	
	Preamplifier PCA (A10).	Defective channel usually has more than 1.8 VDC or oscillation on preamplifier test point. Troubleshoot and repair.	Service Sheets 23, 24, 26
	Meter Amplifier not properly calibrated.	Adjust.	Page 5-26 Paragraph 5-72

Table 5-22. Direct Record/Reproduce (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Output level too low. (Should be adjustable from 0.5 to 5V PK to PK when recording was made at 0 dB input level). (continued)	Direct Record/Reproduce PCA defective.	Isolate problem between record and reproduce section by interchanging PCA's. Troubleshoot and repair. Integrated circuits are likely to fail.	Service Sheets 26, 27
Output amplitude falls outside the ±3 dB specification within the pass band (refer to Page 5-21, paragraph 5-59 for direct frequency response test).	Dirty Record and Reproduce heads.	Clean tape path.	Page 3-24 Paragraph 3-96
	Poor quality tape with poor high frequency response.	Replace with recommended tape.	Page 3-1 Paragraph 3-7
	Equalizer jumps not properly set.	Check jumpers and reposition as required.	Page 3-9 Paragraph 3-21
	Data PCA not properly calibrated.	Calibrate.	Page 5-32 Paragraph 5-83
	Failure in Direct Data PCA.	Troubleshoot and repair Data PCA. If band pass is OK on some speeds but outside the specification on others, the problem may be caused by a defective F.E.T. switch (Q201 thru Q220).	Service Sheets 26, 27
	Severely worn recorder Record/Reproduce head causes the signal to fall off at upper band edge.	Replace head.	Page 5-41 Paragraph 5-109
Input level adjust will not come up to 0 dB level on the meter.	Operate/calibrate switch is incorrectly set.	Switch to operate mode when using INPUT BNC on data channel.	Page 3-9 Paragraph 3-20
	Input signal too low in amplitude.	Increase the amplitude of the input signal.	Page 3-9 Paragraph 3-20
	Meter amplifier not properly calibrated.	Adjust.	Page 5-26 Paragraph 5-72
	Metered channel select PCA switches.	Clean the switch contacts or replace switch.	Page 5-52 Paragraph 5-144
	Input amplifier circuit defect.	Troubleshoot and repair.	Service Sheets 26, 27
	Meter amplifier defect.	Troubleshoot and repair.	Service Sheet 6

Table 5-23. Voice Channel

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Voice channel will not record or reproduce.	Microphone plug not fully seated.	Push plug firmly into socket.	Page 3-10 Paragraph 3-27
	Microphone button not fully depressed.	Press button firmly while making voice recording.	Page 3-10 Paragraph 3-27
	Defective microphone.	Replace.	
	Bias oscillator defective.	Troubleshoot and repair Speed/Bias PCA A4.	Service Sheet 8
	Voice Record/Reproduce PCA defective.	Troubleshoot and repair voice record reproduce PCA (A8). Inspect microphone and head-phone jacks carefully.	Service Sheets 18, 19
Voice recording weak or poor fidelity.	Voice bias level incorrect.	Recalibrate.	Page 5-28 Paragraph 5-74
	Defective voice circuits.	Troubleshoot and repair voice PCA (A8).	Service Sheets 18, 19

Table 5-24. Calibrator

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Calibrator +DC -DC, and PK-AC ranges inoperative.	Operate/calibrate switch not depressed to "CALIBRATE" on Direct or FM Data PCA.	Switch to calibrate.	
	Electrical short between top, center Calibrator/Servo PCA (A7) PCA Board mounting nut and output circuit.	Install insulating washer (such as P/N 3050-0003) between mounting nut and PC board.	Page 7-49 Figure 7-26
	Calibrator/Servo PCA (A7) circuit failure.	Troubleshoot and repair. The Low Pass Filter (U3) is suspect.	Service Sheet 17
AC Calibrator defective. (DC Calibration Modes OK.)	Component failure in AC Calibrator Circuits which are located on the calibrator/servo PCA (A7). Most likely the problem is in the sine wave synthesizer (U4, U5) AC Amplifier (U2) or 8 kHz oscillator (U1).	Troubleshoot and repair.	Service Sheet 17

Table 5-24. Calibrator (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Calibrator inaccurate in AC, +DC and -DC modes.	+10.5V and -10.5V power supplies out of tolerance.	Adjust +10.5V supply.	Page 5-25 Paragraph 5-69
		Troubleshoot and repair +10.5 Vdc and -10.5 Vdc regulators on the meter amplifier PCA (A3).	Service Sheets 5, 6
	Calibrator/Servo PCA (A7) defect.	Troubleshoot and repair calibrator voltage attenuator (R31, 32, 33, 34, 37, 38, 39, 40, 41) and low pass filter (U3).	Service Sheet 17

Table 5-25. Meter

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
DC meter readings offset on all data channels.	Meter amplifier offset (A3R19) improperly adjusted.	Adjust meter.	Page 5-26 Paragraph 5-72
	Meter amplifier PCA (A3) is defective. The amplifier U4 is likely to cause an offset problem.	Troubleshoot and repair.	Service Sheet 6
Meter Pointer binds or sticks.	Meter movement defective.	Replace Meter (M1) and Meter Amplifier PCA (A3).	Page 5-52 Paragraph 5-146
Improper meter reading on one or two channels only.	Metered channel selector switch (S1).	Clean switch contacts or replace switch.	Service Sheet 13
	FM or Direct PCA input circuit defect.	Troubleshoot and repair.	Service Sheets 22, 25, 26, 27
Meter reads incorrectly in PK -AC mode.	Input signals less than specified duty cycle. Meter specified for ±1/2 dB accuracy with 20 - 100% duty cycle.	For very low duty cycle signals use an oscilloscope to monitor output and to adjust input level control for optimum recording.	
	Meter amplifier malfunction.	Check A3U1, U2, U3 circuits.	Service Sheet 6

Table 5-26. Overlap (Option 070)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Overlap option totally inoperative.	Gain set too low (A9R9).	Adjust gain for 3V pk/pk max. signal at TP2 with empty supply reel.	Page 5-35 Paragraph 5-84
	Circuit failure before test point 4.	Troubleshoot and repair.	Service Sheets 20, 21

Table 5-26. Overlap (Option 070) (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
Overlap recorder does not place following recorder in FORWARD RECORD but STOPS or rewinds properly before the end of tape.	Cable wired properly to remotely control the following recorder or faulty connection.	Check the following connections of A24J2 Remote Control Connectors: 1. Pin 4 of overlap recorder to Pin 49 of following recorder. 2. Pin 5 of overlap recorder to Pin 22 of following recorder.	Page 2-4 Figure 2-4
	Output buffers defective (A9U6A or U6B).	Replace.	Service Sheets 20, 21
Overlap occurs with too much tape left on supply reel (over 1/4 inch depth).	Gain adjustment (A9R9) set too high.	Adjust GAIN for 3V pk/pk max. signal at TP2 with empty sup-reel.	Page 5-35 Paragraph 5-84
	Preamplifier A9U2, threshold detector U3A) Buffer/Delay (U3B) or threshold detector (U3C) defective.	Troubleshoot and replace defective component.	Service Sheets 20, 21
Overlap time incorrect (adjustable for 20 to 120 seconds).	Time adjustment (A9R19) not calibrated for desired overlap time.	Adjust variable delay.	Page 5-35 Paragraph 5-84
	A9U7 variable delay circuit.	Troubleshoot and replace defective component.	Service Sheets 20, 21
Recorder does not STOP or REWIND properly when in overlap mode, but it provides proper commands to place following recorder in FORWARD RECORD.	Variable Delay (A9U5A or U7) Stop rewind One-shot (A9U8) or Inverter (A9U6D) is defective.	Troubleshoot and replace defective component.	Service Sheets 20, 21

Table 5-27. HP-IB (Option 007)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
No response one or more modes of operation.	Address switches not set to correct address code.	Set switches to correct position.	Page 3-16 Paragraph 3-54
	Bad connection, broken leads or terminals at HP-IB I/O Connector.	Inspect, repair and connect as necessary.	Page 5-54 Paragraph 5-158
	Bent, broken or mis-inserted pins at ribbon cable connections to either the HP-IB Module or the mother board.		

Table 5-27. HP-IB (Option 007) (Continued)

PROBLEM	POSSIBLE CAUSE	ACTION	REFERENCE
No response one or more modes of operation. (Continued)	Defective PCA's.	Replace PCA.	Page 5-54 Paragraph 5-158 Service Sheets 28, 29
Will not switch modes.	Defective PCA. Especially interface PCA (A19).	Troubleshoot and repair.	Page 5-54 Paragraph 5-158 Service Sheets 28, 29

SECTION VI

PARTS LIST

6-1. INTRODUCTION.

6-2. This section contains part information for the Model 3964A/3968A Instrumentation Tape Recorder. Included herein is a listing of replaceable chassis parts and parts ordering information.

6-3. CHASSIS PARTS.

6-4. Chassis mounted parts for the Model 3964A/3968A are listed in Tables 6-2 through 6-7.

6-5. CIRCUIT BOARD PARTS.

6-6. Parts located on printed circuit assembly (PCA's) are listed in tabular form adjacent to the schematic diagram of the PCA. Refer to Section VII for these tables.

6-7. ORDERING INFORMATION.

6-8. To obtain replacement parts, address an order or inquiry to the nearest Hewlett-Packard Sales and Service Office. The order should include the part number, description, instrument model and serial numbers, and location of part. A list of sales and service offices is located at the end of this manual.

6-9. CODE LIST OF MANUFACTURERS.

6-10. Table 6-1 lists the five digit code numbers assigned to the manufacturer of parts in the HP 3964A/3968A. These code numbers appear with the parts in Tables 6-2 through 6-7 as an aid for ordering replacement parts directly from the manufacturer.

Table 6-1. Code List of Manufacturers

Mfr No.	Manufacturer Name	Address
0006A	Kimball and Stark	
0160G	Allen-Bradley Company	Milwaukee, Wi.
0203G	Motorola Semiconductor Products	Phoenix, Az.
0217B	Airco Speer Electronics Div. Air RDCN Company	Nogales, Az.
0217J	Amatom Electronics Hardware Div. of Mite	New Rochelle, N.Y.
0223G	Fairchild Semiconductor Division	Mountain View, Ca.
0239B	C and K Components, Inc.	Watertown, Ma.
0299E	MEPCO/Electra Corporation	Mineral Wells, Tx.
0329B	Corning Glass Works (Bradford)	Bradford, Pa.
0331F	Specialty Connector Company, Inc.	Indianapolis, In.
0340F	National Semiconductor Corporation	Santa Clara, Ca.
0365A	MEPCO/Electra Corporation	San Diego, Ca.
0369E	Triridge Corporation	Pittsburgh, Pa.
0420J	Sprague Electric Company	North Adams, Ma.
0447E	Cambridge Thermionic Corporation	Cambridge, Ma.
0449B	Centralab Electronics Division – Globe-Union, Inc.	Milwaukee, Wi.
0460D	Federal Screw Products Company	Chicago, Il.
0505G	Switchcraft, Inc.	Chicago, Il.
0519A	Lee Spring Company	Brooklyn, N.Y.
0G791	Thompson Bremer Division Vare	Chicago, Il.
08806	General Electric Co. Miniature Lamp Production Dept.	Cleveland, Oh.
28480	Hewlett-Packard Company, Division 00 Corporate	Palo Alto, Ca.
28520	Heyman Manufacturing Company	Kenilworth, N.J.
31918	IEE/Shadow, Inc.	Minneapolis, Mn.
34344	Motorola, Inc.	Franklin Park, Il.
72136	Electro Motive Corporation Sub IEC	Willimantic, Ct.
73138	Beckman Instruments, Inc., Helipot Division	Fullerton, Ca.
76381	3M Company	St. Paul, Mn.
78189	Illinois Tool Works, Inc. Shakeproof	Elgin, Il.
79963	Zierick Manufacturing Company	Mt. Kisco, N.Y.
84411	TRW Capacitor Division	Ogallala, Ne.

Table 6-2. Accessory Kit and Extender Board

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
			TABLE 6-1. ACCESSORY KIT & EXTENDER BDS		
	03968-61001	1	ACCESSORY KIT	28480	03968-61001
	0960-0316	1	MICROPHONE- DYNM	28480	0960-0316
	1251-0086	1	CONNECTOR 50-PIN M MICRO RIBBON	71785	57-30500-375
	1540-0182	1	CASE-ACCESS POLYETH 13.5LG 10WD 3.125DP	53718	RY3-1/8-2768
	2140-0452	10	LAMP-INCAND 24VDC 30MA T-1-3/4-BULB	28480	2140-0452
	8120-2233	2	CABLE ASSY 22AWG 1-CNDCT BLK-JKT .064-OD	00541	PM080-18
	8500-1251	1	CLEANER FOR MAGNETIC HEADS	01329	H-8500-1251
	8520-0023	1	APPLICATOR, COTTON TIPPED 6.0" LG	59728	2942-C20
	8710-0566	1		28480	8710-0566
	8710-0957	1	WAND:TUNING TOOL 2.0" LG	00000	OBD
	03968-60960	1	EXTENDER PCA, CONTROL	28480	03968-60960
	03968-60965	1	EXTENDER PCA, DATA	28480	03968-60965
	03968-60951	1	EXTENDER PCA (OPTION 001 ONLY)	28480	03968-60951
	03968-60952	1	EXTENDER PCA (OPTION 007 ONLY)	28480	03968-60952

Table 6-3. Model 3964A/3968A Assembly Parts List

Item No.	Ref Des	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
1		03968-60690		TRANSPORT COMMON	28480	03968-60690
2		03968-60620		TRANSPORT COVER ASSEMBLY	28480	03968-60620
3	A2	03968-60600		PCA, MOTOR DRIVER/+5V(A) REGULATOR	28480	03968-60600
4	A4	03968-60560		PCA, SPEED CONTROL/BIAS OSCILLATOR	28480	03968-60560
5	A6	03968-60540		PCA, MODE CONTROL	28480	03968-60540
6	A8	03968-60520		PCA, VOICE CHANNEL/SERVO LOOP	28480	03968-60520
7	A7	03968-60530		PCA, CALIBRATOR/SERVO CONTROL	28480	03968-60530
7	A7	03968-60531		PCA, CALIBRATOR/SERVO CONTROL (OPTION 041)	28480	03968-60531
8	A5	03968-60550		PCA, METER SELECT/POWER DETECTOR	28480	03968-60550
8	A5	03964-60550		PCA, METER SELECT/POWER DETECTOR (3964A)	28480	03964-60550
9	A3	03968-60570		PCA, METER AMPLIFIER/10.5V REGULATOR	28480	03968-60570
10	A1	03968-60585		PCA, +5V(B) REGULATOR	28480	03968-60585
				NOTE		
				THE FOLLOWING ASSEMBLIES ARE DATA PCA'S AND CAN BE FM OR DIRECT CHANNELS. THE FM ASSEMBLIES ARE ORDERED AS OPTION 001 AND THE DIRECT ASSEMBLIES AS OPTION 002.		
				3968A DATA ASSEMBLIES		
11	A11	03964-60505		PCA, FM RECORD/REPRODUCE OR	28480	03964-60505
		03968-60510		PCA, DIRECT RECORD/REPRODUCE	28480	03968-60510
12	A12			SAME AS A11		
13	A13			SAME AS A11		
14	A14			SAME AS A11		
15	A15			SAME AS A11		
16	A16			SAME AS A11		
17	A17			SAME AS A11		
18	A18			SAME AS A11		
				3964A DATA ASSEMBLIES		
11	A11	03964-60505		PCA, FM RECORD/REPRODUCE OR	28480	03964-60505
		03964-60510		PCA, DIRECT RECORD/REPRODUCE	28480	03964-60510
12	A12			SAME AS A11		
13				NOT USED		
14				NOT USED		
15	A13			SAME AS A11		
16	A14			SAME AS A11		
17				NOT USED		
18				NOT USED		
19		03968-00194		PANEL, CONTROL (3968)	28480	03968-00194
		03964-00194		PANEL, CONTROL (3964)	28480	03964-00194
		03964-00195		PANEL, CONTROL (3964A OPTION 009) (BEFORE S/P 1746A)	28480	03964-00915
		03968-00195		PANEL, CONTROL (3968A OPTION 009) (BEFORE S/P 1746A)	28480	03968-00195
20		03968-0071		DATA CHANNEL FILLER PANEL–OLIVE BLACK	28480	03968-0071
		03968-0072		DATA CHANNEL FILLER PANEL–WHITE (OPT 009)	28480	03968-0072

MODEL 3968A

MODEL 3964A

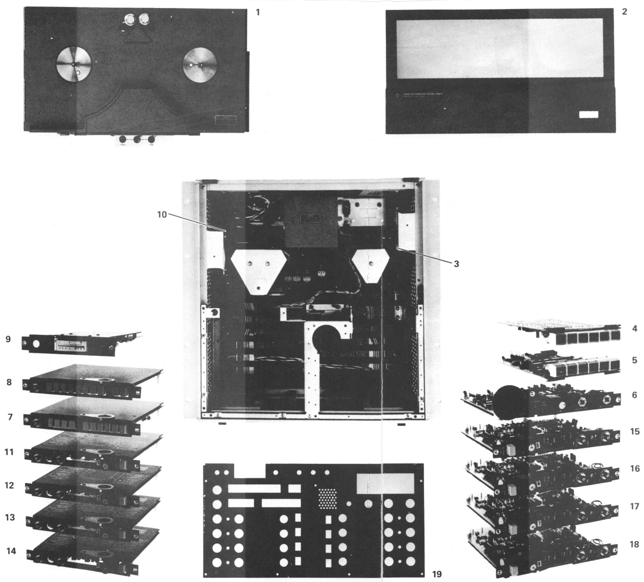


Figure 6-1. Model 3964A/3968A
Assembly Identification

Table 6-4. Model 3964A/3968A Tape Transport Parts List

Item No.	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
1	2200-0165	5	SCREW-MACH 4-40 .25-IN-LG 82 DEG	28480	2200-0165
2	03968-21631	2	PIVOT	28480	03968-21631
3	03968-60625	1	BRACE	28480	03968-60625
4	2200-0165		SCREW-MACH 4-40 .25-IN-LG 82 DEG	28480	2200-0165
5	03968-21631		PIVOT	28480	03968-21631
6	7120-5221	1	INFORMATION LABEL 2.52-IN-WD 11-IN-LG	28480	7120-5221
7	0510-0591	6	RETAINER—PUSHON CIRC EXT .25DIA	28480	0510-0591
8	03968-00691	1	WINDOW CLAMP	28480	03968-00691
9	0150-0591			28480	0150-0591
10	03968-00685	1	WINDOW, COUNTER	28480	03968-00685
11	03968-00687	1	PLATE, WINDOW	28480	03968-00687
12	03968-20691	1	COVER	28480	03968-20691
13	03968-00680	1	WINDOW	28480	03968-00680
14	2190-0149	1	WASHER-FL MTLC NO.-4 .117-IN-ID	28480	2190-0149
15	2190-0004	2	WASHER-LK INTL T NO.-4 .115-IN-ID	0G791	418-BC EVERLOCK WASHER
16	0590-0075	1	NUT-CAP 4-40-THD .25-THK .25-A/F BRS	73734	8060-NP
17	03968-21629	1	PIVOT	28480	03968-21629
18	03968-60615	1	BRACE	28480	03968-60615
19	2200-0165		SCREW-MACH 4-40 .25-IN-LG 82 DEG	28480	2200-0165
20	03968-21630	1	PIVOT	28480	03968-21630
21	2360-0195	5	SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	28480	2360-0195
22	03968-20620	1	HINGE	28480	03968-20620
23	2360-0191	2	SCREW-MACH 6-32 .188-IN-LG PAN-HD-POZI	28480	2360-0191
24	2200-0138	1	SCREW-MACH 4-40 .188-IN-LG 100 DEG	28480	2200-0138
25	03968-20661	1	PIVOT	28480	03968-20661
26	03968-20665	1	PIN	28480	03968-20665
27	0510-0261	1	RETAINER-RING .094-DIA STL CD-PL	79136	5133-9-8-MD
28	2560-0009	1		28480	2560-0009
29	2190-0017	1	WASHER-LK HLCL NO.-8 .168-IN-ID	28480	2190-0017
30	2190-0419	1	WASHER-FL MTLC NO.-8 .172-IN-ID	28480	2190-0419
31	03968-20631	1		28480	03968-20631
32	2200-0103	2	SCREW-MACH 4-40 .25-IN-LG PAN-HD-POZI	28480	2200-0103
33	03960-00020	2	REEL PIN LEAF SPRING	28480	03960-00020
34	1410-0041	4	BEARING:BALL 5/16 ID	28480	1410-0041
35	03960-20180	2	REEL DRIVE PIN	28480	03960-20180
36	03960-60050	2	REEL HUB ASSEMBLY	28480	03960-60050
37	2200-0165		SCREW-MACH 4-40 .25-IN-LG 82 DEG	28480	2200-0165
38	03968-00635	1	COVER, SHIELD	28480	03968-00635
39	2200-0121	1	SCREW-MACH 4-40 1.125-IN-LG PAN-HD-POZI	28480	2200-0121
40	2190-0108	9	WASHER-LK HLCL NO.-4 .115-IN-ID	28480	2190-0108
41	13409A	1	HEAD, REPRODUCE 3968A	28480	13409A
42*	13411A	1	HEAD, REPRODUCE 3964A	28480	13411A
43	0510-0082	1	RETAINER-RING .125-DIA BE CU	97464	3100-12-BC
44	03960-20010	1	PINCH ROLLER CAP	28480	03960-20010
45	03960-20420	1	PINCH ROLLER	28480	03960-20420
46	1410-0173	1	BEARING:BALL SINGLE ROW DOUBLE SHIELD	21335	PAMV33KDD3 E-9435
47	0510-0811	1	RETAINER-RING .375-DIA CD PL STL	97464	3000X-37-8T-CD
48	2190-0701	1	WASHER-FL MTLC NO.-1/4 .257-IN-ID	86928	5710-63-5
49	03964-00700	1	INSULATOR	28480	03964-00700
50	03964-00750	1	SHIELD, OUTER HEAD	28480	03964-00750
51	2190-0034	3	WASHER-LK HLCL NO.-10 .194-IN-ID	28480	2190-0034
52	2680-0103	1	SCREW-MACH 10-32 .5-IN-LG PAN-HD-POZI	28480	2680-0103
53	2360-0191		SCREW-MACH 6-32 .188-IN-LG PAN-HD-POZI	28480	2360-0191
54	2190-0105	6	WASHER-LK HLCL NO.-6 .141-IN-ID	28480	2190-0105
55	3050-0066	2	WASHER-FL MTLC NO.-6 .147-IN-ID	28480	3050-0066
56	03968-00601	1	BRACKET	28480	03968-00601
57	1460-1113	1	SPRING-CPRSN .437-OD .562-LG MUW	28480	1460-1113
58	1480-0214	1		28480	1480-0214
59	1460-1112	1	SPRING-EXT .187-OD 1.06-LG MUW	28480	1460-1112
60	2200-0151	1	SCREW-MACH 4-40 .75-IN-LG PAN-HD-POZI	28480	2200-0151
61	2190-0004		WASHER-LK INTL T NO.-4 .115-IN-ID	0G791	418-BC EVERLOCK WASHER
62	3050-0222	1	WASHER-FL MTLC NO.-4 .125-IN-ID	28480	3050-0222
63	2260-0002	1	NUT-HEX-DBL-CHAM 4-40-THD .062-THK	28480	2260-0005
64	03968-60200	1	CAPSTAN ASSEMBLY,STD. NEW	28480	03968-60200
	03968-62700	1	CAPSTAN ASSEMBLY,STD. REBUILT	28480	03968-62700
	03968-60710	1	CAPSTAN ASSEMBLY, OPTION 041, NEW	28480	03968-60710
	03968-62710	1	CAPSTAN ASSEMBLY, OPTION 041, REBUILT	28480	03968-62710
	03964-60700	1	CAPSTAN ASSEMBLY, STD. NEW	28480	03964-60700
	03964-62700	1	CAPSTAN ASSEMBLY, STD. REBUILT	28480	03964-62700
	03964-60710	1	CAPSTAN ASSEMBLY, OPTION 041, NEW	28480	03964-60710
	03964-62710	1	CAPSTAN ASSEMBLY, OPTION 041, REBUILT	28480	03964-62710
65	03968-20745	1	BASE, TAPE GUIDE	28480	03968-20745
66	03968-20230	1	POST, TAPE GUIDE	28480	03968-20230
67	03968-20740	1	CAP, TAPE GUIDE	28480	03968-20740
68	2200-0175	1	SCREW-MACH 4-40 1.25-IN-LG 82 DEG	28480	2200-0175

Table 6-4. Model 3964A/3968A Tape Transport Parts List (Continued)

Item No.	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
69	03968-20625	1	SHIELD, INTERHEAD	28480	03968-20625
70	13408A	1	HEAD, RECORD, 3968A	28480	13408A
71	13410A	1	HEAD, RECORD, 3964A	28480	13410A
72	2190-0306	1		28480	2190-0306
73	03968-20694	1	SCREW, INSULATED	28480	03968-20694
74	2680-0099	2	SCREW-MACH 10-32 .375-IN-LG PAN-HD-POZI	28480	2680-0099
75	2190-0034		WASHER-LK HLCL NO.-10 .194-IN-ID	28480	2190-0034
76	03960-60810	2	MOTOR ASSEMBLY, REEL	28480	03960-60810
77	3050-0470	2	WASHER-FL MTLC NO.-1/4 .281-IN-ID	28480	3050-0470
78	03960-20290	2	SPACER, REEL	28480	03960-20290
79	0510-0040	2	RETAINER-RING .312-DIA STL CD-PL	79136	5100-31-S-MD
80	2190-0373	2	WASHER-FL MTLC NO.-5/16 .314-IN-ID	28480	2190-0373
81	1410-0041		BEARING:BALL 5/16 ID	28480	1410-0041
82	1251-3977	3	CONNECTOR 2-PIN F UTILITY	28480	1251-3977
83	1251-2623	3	CONTACT-CONN MALE CRP .062-CONT-SZ	27264	02-06-2103
84	2190-0027	2	WASHER-LK INTL T NO.-1/4 .256-IN-ID	78189	1914-00
85	2190-0006	2	WASHER-LK HLCL NO.-6 .141-IN-ID	28480	2190-0006
86	2200-0103		SCREW-MACH 4-40 .25-IN-LG PAN-HD-POZI	28480	2200-0103
87	03960-00020		REEL PIN LEAF SPRING	28480	03960-00020
88	1410-0041		BEARING:BALL 5/16 ID	28480	1410-0041
89	03960-20180		REEL, DRIVE PIN	28480	03960-20180
90	03960-60050		REEL HUB ASSEMBLY	28480	03960-60050
91	2680-0099		SCREW-MACH 10-32 .375-IN-LG PAN-HD-POZI	28480	2680-0099
92	2190-0034		WASHER-LK HLCL NO.-10 .194-IN-ID	28480	2190-0034
93	03960-60810		MOTOR ASSEMBLY, REEL	28480	03960-60810
94	3050-0470		WASHER-FL MTLC NO.-1/4 .281-IN-ID	28480	3050-0470
95	03960-20290		SPACER, REEL	28480	03960-20290
96	0510-0040		RETAINER-RING .312-DIA STL CD-PL	79136	5100-31-S-MD
97	2190-0373		WASHER-FL MTLC NO.-5/16 .314-IN-ID	28480	2190-0373
98	1410-0041		BEARING:BALL 5/16 ID	28480	1410-0041
99	1251-3977		CONNECTOR 2-PIN F UTILITY	28480	1251-3977
100	1251-2623		CONTACT-CONN MALE CRP .062-CONT-SZ	27264	02-06-2103
101	2190-0027		WASHER-LK INTL T NO.-1/4 .256-IN-ID	78189	1914-00
102	2190-0006		WASHER-LK HLCL NO.-6 .141-IN-ID	28480	2190-0006
103	03968-20611	1	DECK, TOP	28480	03968-20611
104	03960-60110	1	ROTARY GUIDE, LEFT HAND	28480	03960-60110
105	03960-60120	1	ROTARY GUIDE, RIGHT HAND	28480	03960-60120
106	03968-20651	1	HINGE, DECK	28480	03968-20651
106A	03964-20670	2	HEAD COVER PINS	28480	03964-20670
107	02968-01601	1	COVER, HEAD	28480	03968-01601
108	03968-20681	1	HINGE, RIGHT HAND	28480	03968-20681
109	03968-21611	1	HINGE, COVER	28480	03968-21611
110	2200-0167	1	SCREW-MACH 4-40 .375-IN-LG 82 DEG	28480	2200-0167
111	3050-0388	1	WASHER-FL NM NO.-6 .14-IN-ID .312-IN-OD	73734	104317
112	03968-60601	1	SHIELD ASSEMBLY, PREAMPLIFIER	28480	03968-60601
113	03968-60590	1	PREAMPLIFIER, PCA, 3968A (A10)	28480	03968-60590
114	03964-60590	1	PREAMPLIFIER, PCA, 3964A (A10)	28480	03964-60590
115	2190-0105		WASHER-LK HLCL NO.-6 .141-IN-ID	28480	2190-0105
116	2360-0207	1	SCREW-MACH 6-32 .875-IN-LG PAN-HD-POZI	28480	2360-0207
117	03968-00650	1	SHIELD, PREAMPLIFIER	28480	03968-00650
118	2190-0315	1	WASHER-FL MTLC NO.-5 .13-IN-ID .25-IN-OD	28480	2190-0315
119	2190-0108		WASHER-LK HLCL NO.-4 .115-IN-ID	28480	2190-0108
120	2200-0139	1	SCREW-MACH 4-40 .25-IN-LG PAN-HD-POZI	28480	2200-0139
121	2360-0195		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	28480	2360-0195
122	2190-0105		WASHER-LK HLCL NO.-6 .141-IN-ID	28480	2190-0105
123	3050-0066		WASHER-FL MTLC NO.-6 .147-IN-ID	28480	3050-0066
124	0400-0085	1	INSULATOR-BSHG-FLG SNAP-IN .875-ID	28520	SB-1093-14
125	03968-20641	1	PANEL SUPPORT, 3968A	28480	03968-20641
126	03964-20641	1	PANEL SUPPORT, 3964A	28480	03964-20641
127	3101-1702	1	SWITCH-TGL SUBMIN SPDT NS .02A 20VAC/DC	09353	7101-PYZBE
128	0590-0836	1	NUT-HEX-SGL-CHAM 1/4-40-THD .15-THK	28480	0590-0836
129	3050-0389	2	WASHER-FL NM NO.-1/4 .26-IN-ID .5-IN-OD	28480	3050-0389
130	2200-0149	1	SCREW-MACH 4-40 .625-IN-LG PAN-HD-POZI	28480	2200-0149
131	2190-0108		WASHER-LK HLCL NO.-4 .115-IN-ID	28480	2190-0108
132	1990-0521	1	LED-VISIBLE LUM-INT=2.2MCD IF=50MA-MAX	28480	1990-0521
133	3050-0389		WASHER-FL NM NO.-1/4 .26-IN-ID .5-IN-OD	28480	3050-0389
134	03968-20616	1	BUMPER	28480	03968-20616
135	0570-0570	1	PLUNGER, SPRING, 10-32 UNF THREAD 0.468"	01226	NM-52N
136	0520-0136	1	SCREW-MACH 2-56 .625-IN-LG PAN-HD-POZI	28480	0520-0136
137	0520-0137	1	SCREW-MACH 2-56 .75-IN-LG PAN-HD-POZI	28480	0520-0137
138	3101-1240		SWITCH-SENS SPDT SUBMIN 5A 250VAC	91929	311SM6-T
	3101-1240	2	SWITCH-SENS SPDT SUBMIN 5A 250VAC	91929	311SM6-T
139	03960-20610	1	SPACER	28480	03960-20610
140	03960-20600	1	SPACER	28480	03960-20600
141	03960-61012	1	DAMPER ASSEMBLY	28480	03960-61012
142	0340-0038	1	TERMINAL-STUD DBL-TUR PRESS-MTG	28480	0340-0038
143	0340-0039	1	TERMINAL BUSHING - TEFLON; MOUNTS IN	28480	0340-0039

Table 6-4. Model 3964A/3968A Tape Transport Parts List (Continued)

Item No.	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
144	2190-0045	1	WASHER-LK HLCL NO.-2 .088-IN-ID	28480	2190-0045
145	0610-0001	1	NUT-HEX-DBL-CHAM 2-56-THD .062-THK	28480	0615-0002
146	2190-0416	3	WASHER-FL MTLC NO.-4 .125-IN-ID	28480	2190-0416
147	2190-0108		WASHER-LK HLCL NO.-4 .115-IN-ID	28480	2190-0108
148	2200-0141	5	SCREW-MACH 4-40 .312-IN-LG PAN-HD-POZI	28480	2200-0141
149	2190-0476	1	WASHER-LK 82 CTSK EXT T NO.-4 .116-IN-ID	78189	1504-00(ST,CD,)
150	2200-0165		SCREW-MACH 4-40 .25-IN-LG 82 DEG	28480	2200-0165
151	1460-1172	1	SPRING-CPRSN	28480	1460-1172
152	03960-40130	1	SPRING RETAINER	28480	03960-40130
153	03960-60600	2	BRAKE BAND RIGHT HAND	28480	03960-60600
154	03960-20560	1	PULLEY, COUNTER	28480	03960-20560
155	0905-0544	1	"O" RING, 3.487"ID .103-XSECT-DIA EPR	00000	OBD
156	03960-01024	1	BRACKET, COUNTER	28480	03960-01024
157	2190-0416		WASHER-FL MTLC NO.-4 .125-IN-ID	28480	2190-0416
158	2190-0108		WASHER-LK HLCL NO.-4 .115-IN-ID	28480	2190-0108
159	2200-0141		SCREW-MACH 4-40 .312-IN-LG PAN-HD-POZI	28480	2200-0141
159A	03964-60012	1	BRAKE SOLENOID ASSEMBLY (INCLUDES ITEMS 160, 161, 165, 166, 167, 168)	28480	03964-60012
160	1251-2623		CONTACT-CONN MALE CRP .062 CONT-8Z	27264	02-06-2103
161	1251-3977		CONNECTOR 2-PIN F UTILITY	28480	1251-3977
162	03968-00051	1	SOLENOID BRACKET	28480	03968-00051
163	2190-0108		WASHER-LK HLCL NO.-4 .115-IN-ID	28480	2190-0108
164	2200-0147	1	SCREW-MACH 4-40 .5-IN-LG PAN-HD-POZI	28480	2200-0147
165	0491-0054	1	SOLENOID-LIN 24VDC 450Z PULL-@-.125 IN	73949	T12X13CONT24D
166			NOT USED		
167			NOT USED		
168			NOT USED		
169	03960-00980	2	SOLENOID LINKAGE	28480	03960-00980
170	2200-0141		SCREW-MACH 4-40 .312-IN-LG PAN-HD-POZI	28480	2200-0141
171	2190-0108		WASHER-LK HLCL NO.-4 .115-IN-ID	28480	2190-0108
172	2190-0416		WASHER-FL MTLC NO.-4 .125-IN-ID	28480	2190-0416
173	2200-0091	1	SCREW-MACH 4-40 .562-IN-LG PAN-HD-POZI	28480	2200-0091
174	03960-20995	1	BUSHING, BRAKE	28480	03960-20995
175	03960-00980		SOLENOID LINKAGE	28480	03960-00980
176	2200-0141		SCREW-MACH 4-40 .312-IN-LG PAN-HD-POZI	28480	2200-0141
177	2190-0108		WASHER-LK HLCL NO.-4 .115-IN-ID	28480	2190-0108
178	03960-20210	2	BUSHING, BRAKE	28480	03960-20210
179	3050-0178	2	WASHER-FL MTLC NO.-1/4 .251-IN-ID	28480	3050-0178
180	03960-01018	1	BELL CRANK	28480	03960-01018
181	1460-1207	2	SPRING-EXT .187-OD 1.044-LG SST	28480	1460-1207
182	03960-60600		BRAKE BAND, LEFT	28480	03960-60600
183	2260-0009	2	NUT-HEX-W/LKWR 4-40-THD .094-THK .25-A/F	28480	2260-0011
184	2200-0143	1	SCREW-MACH 4-40 .375-IN-LG PAN-HD-POZI	28480	2200-0143
185	2260-0009		NUT-HEX-W/LKWR 4-40-THD .094-THK .25-A/F	28480	2260-0011
186	1460-1207		SPRING-EXT .187-OD 1.044-LG SST	28480	1460-1207
187	03960-01016	1	BELL CRANK	28480	03960-01016
188	3050-0178		WASHER-FL MTLC NO.-1/4 .251-IN-ID	28480	3050-0178
189	03960-20210		BUSHING	28480	03960-20210
190	2190-0108		WASHER-LK HLCL NO.-4 .115-IN-ID	28480	2190-0108
191	2200-0141		SCREW-MACH 4-40 .312-IN-LG PAN-HD-POZI	28480	2200-0141
192	03968-60680	1	CABLE ASSEMBLY, PREAMP 3968A (W7)	28480	03968-60680
193	03964-60680	1	CABLE ASSEMBLY, PREAMP 3964A (W7)	28480	03964-60680
194	03968-60670	1	CABLE ASSEMBLY, RECORD 3968A (W6)	28480	03968-60670
195	03964-60670	1	CABLE ASSEMBLY, RECORD 3964A (W6)	28480	03964-60670
196	03968-00132	1	CLAMP, CABLE	28480	03968-00132
197	2360-0195		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	28480	2360-0195
198	2190-0105		WASHER-LK HLCL NO.-6 .141-IN-ID	28480	2190-0105
199	1251-4006	5	CONNECTOR 10-PIN F RECTANGULAR	28480	1251-4006
200	1251-4006		CONNECTOR 10-PIN F RECTANGULAR	28480	1251-4006
201	1251-3979	1	CONNECTOR 9-PIN F UTILITY	28480	1251-3979
202	1251-3982	3	CONNECTOR 2-PIN F UTILITY	28480	1251-3982
203	1400-0611	1	CLAMP-CA .1-DIA 1-WD PVC	76381	3484-1000
204	0510-0800	1	CLAMP-CA .5-IN-WD ETH-CELL	28480	0510-0800
205	2360-0195		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	28480	2360-0195
206	2190-0105		WASHER-LK HLCL NO.-6 .141-IN-ID	28480	2190-0105
207	2190-0452	2	WASHER;RECTANGULAR #6	95987	D6-140
208	1251-3982		CONNECTOR 2-PIN F UTILITY	28480	1251-3982
209	1251-3978	1	CONNECTOR 9-PIN F	27264	09-50-7091
210	1251-3118	1	CONNECTOR 20-PIN F RECTANGULAR	76381	3421-0000
211	1251-4006		CONNECTOR 10-PIN F RECTANGULAR	28480	1251-4006
212	1251-2615	2	CONNECTOR 16-PIN M RECTANGULAR	76381	3416
213	1251-3202	1	CONNECTOR 15-PIN F POST TYPE	27264	09-50-7151
214	03968-60630	1	WIRE HARNESS, TRANSPORT CONTROL (W8)	28480	03968-60630
215	0510-0787	1	CLAMP-CA .312-DIA .5-WD ETH-CELL	28480	0510-0787
216	2360-0195		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	28480	2360-0195
217	2190-0105		WASHER-LK HLCL NO.-6 .141-IN-ID	28480	2190-0105
218	2190-0452		WASHER;RECTANGULAR #6	95987	D6-140

Table 6-4. Model 3964A/3968A Tape Transport Parts List (Continued)

Item No.	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
219	1251-3982		CONNECTOR 2-PIN F UTILITY	28480	1251-3982
220	03968-60660	2	CABLE ASSEMBLY, REPRODUCE 3968A, (W4)	28480	03968-60660
221	03968-60660		CABLE ASSEMBLY, REPRODUCE 3964/8A (W5)	28480	03968-60660
222	1251-4006		CONNECTOR 10-PIN F RECTANGULAR W4P1 (3968A)	28480	1251-4006
223	1251-4006		CONNECTOR 10-PIN F RECTANGULAR W5P1 (3964/8A)	28480	1251-4006
224	1251-2615		CONNECTOR 16-PIN M RECTANGULAR	76381	3416
225	03968-00643	1	PLATE, SW GRAY	28480	03968-00643

TAPE TRANSPORT ASSEMBLY

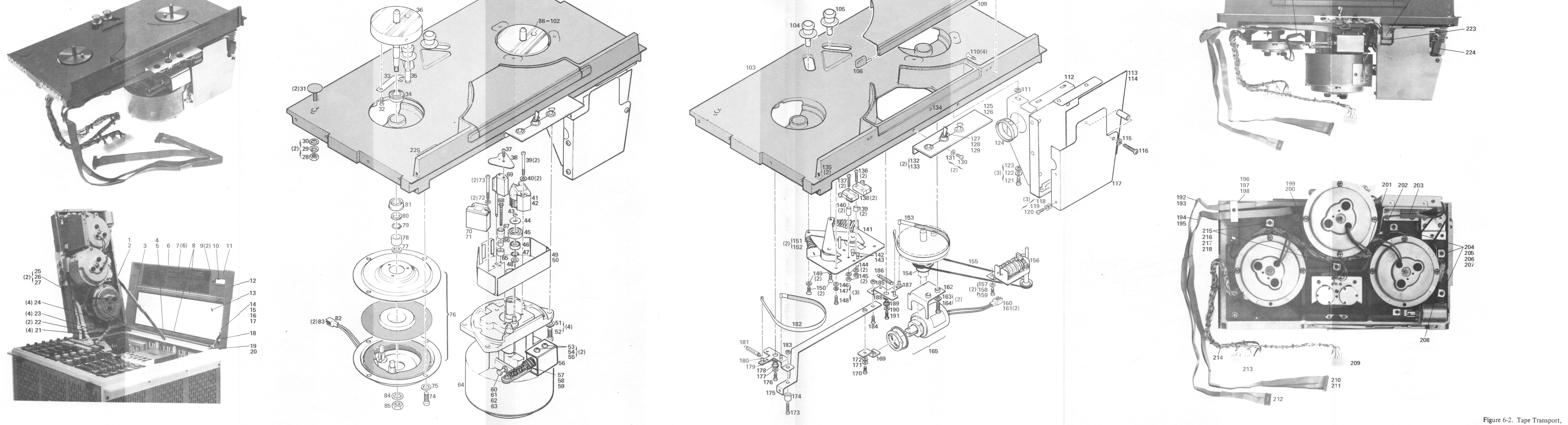


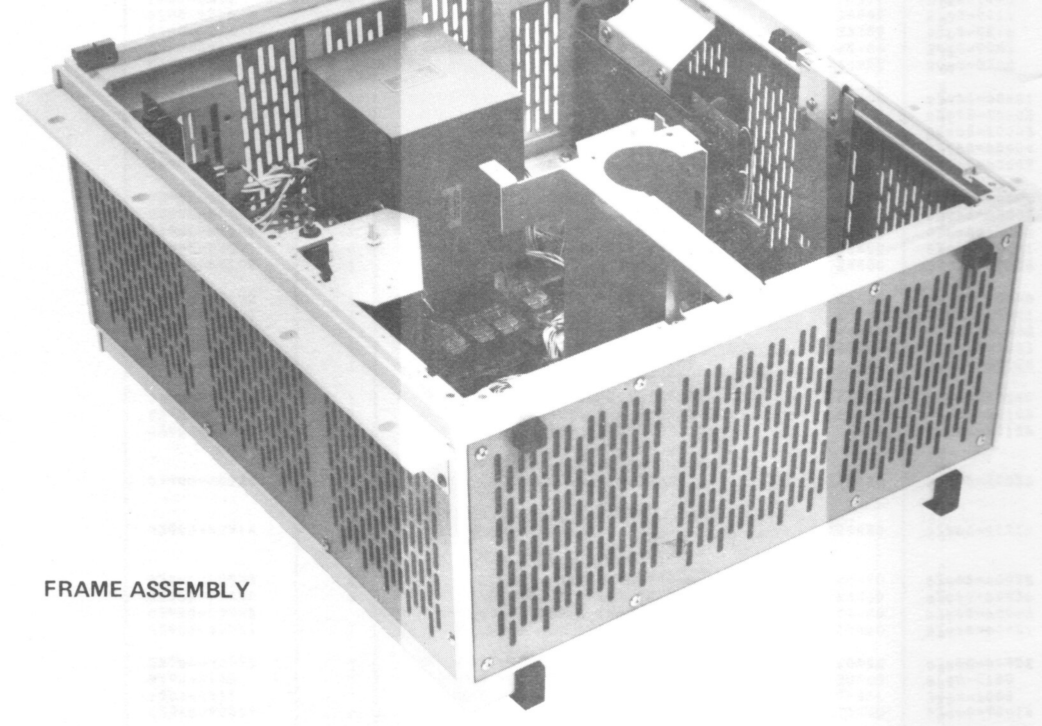
Figure 6-2. Tape Transport, Exploded View

Table 6-5. Main Frame Parts List

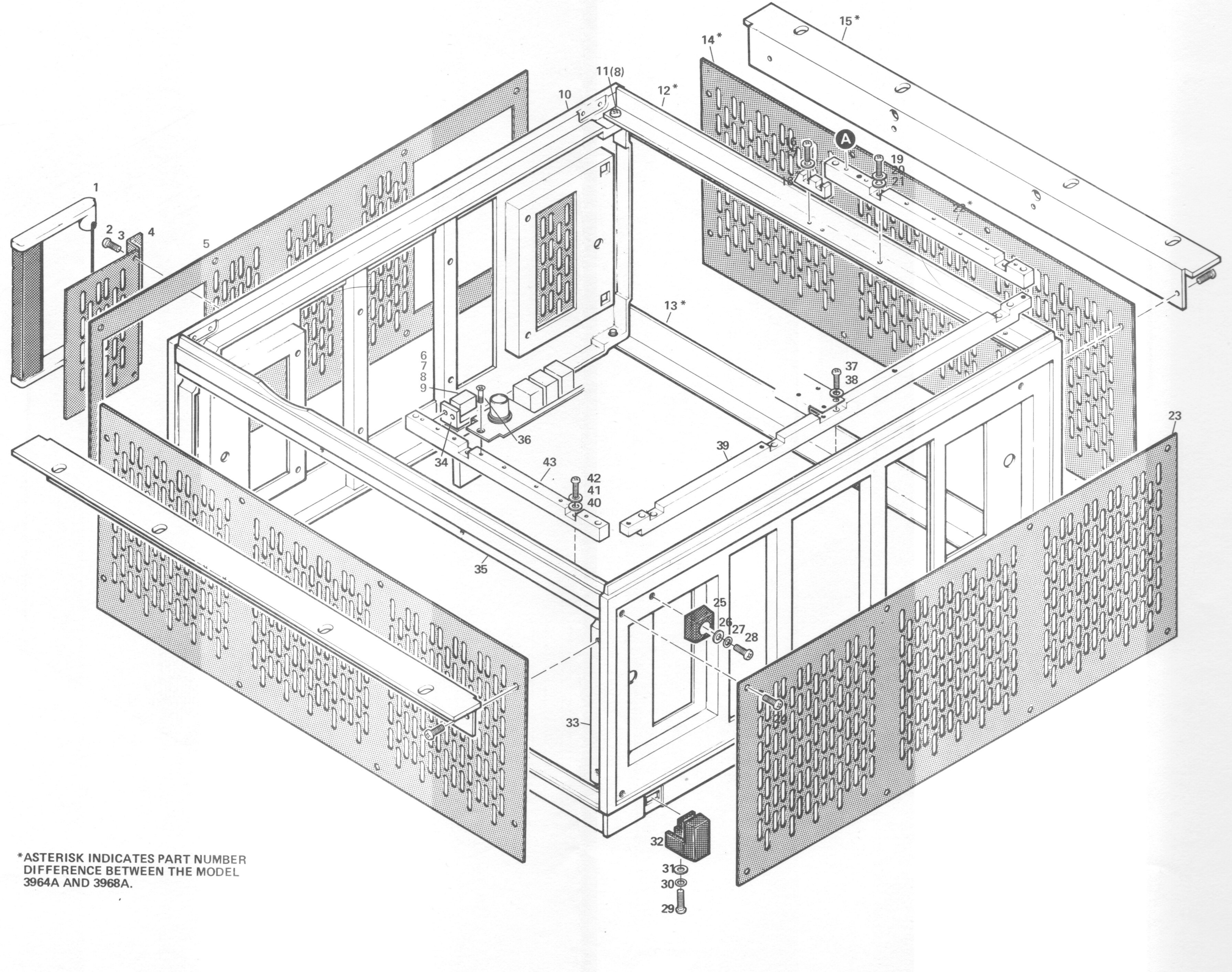
Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
1	03968-60011	1	HANDLE ASSEMBLY	28480	03968-60011
2	2510-0105	1	SCREW-MACH 8-32 .438-IN-LG PAN-HD-POZI	28480	2510-0105
3	2190-0017	2	WASHER-LK HLCL NO. 8 .168-IN-ID	28480	2190-0017
4	03968-00141	1	RETAINER, HANDLE	28480	03968-00141
5	03968-00151	1	COVER, REAR	28480	03968-00151
6	3101-2200	1	SWITCH-PB 4PDT ALTNG 4A 250VAC	28480	3101-2200
7	3101-1629	1	SWITCH;BOTTOM WH	28480	3101-1629
8	2190-0427		WASHER-LK HLCL NO. 2 .088-IN-ID	04600	1350
9	0520-0127	2	SCREW-MACH 2-56 .188-IN-LG PAN-HD-POZI	28480	0520-0127
10	03968-20131	1	FRAME, REAR	28480	03968-20131
11	2360-0276		SCREW-MACH 6-32 .375-IN-LG TR-HD-PHL	28480	2360-0276
12	03968-20151	1	RAIL, TOP RIGHT (3968A)	28480	03968-20151
	03964-20151	1	RAIL, TOP RIGHT (3964A)	28480	03964-20151
13	03968-20171	2	RAIL, BOTTOM (3968A)	28480	03968-20171
	03964-20171	2	RAIL, BOTTOM (3964A)	28480	03964-20171
14	03968-00171	1	PANEL, SIDE (3968A)	28480	03968-00171
	03964-00171	1	PANEL, SIDE (3964A)	28480	03964-00171
15	03968-20401	1	EAR, RACK (3968A)	28480	03968-20401
	03964-20401	1	EAR, RACK (3964A)	28480	03964-20401
16	2200-0147	1	SCREW-MACH 4-40 .5-IN-LG PAN-HD-POZI	28480	2200-0147
17	2190-0108		WASHER-LK NM NO. 4 .115-IN-ID .226-IN-OD	28480	2190-0108
18	03968-20050	1	GUIDE, TRANSPORT	28480	03968-20050
19	2200-0149	2	SCREW-MACH 4-40 .625-IN-LG PAN-HD-POZI	28480	2200-0149
20	2190-0108		WASHER-LK NM NO. 4 .115-IN-ID .226-IN-OD	28480	2190-0108
21	2190-0315	2	WASHER-FL MTLC NO. 5 .13-IN-ID .25-IN-OD	28480	2190-0315
22	03968-20085	1	SPACER, RIGHT (3968A)	28480	03968-20085
	03964-20085	1	SPACER, RIGHT (3964A)	28480	03964-20085
23	03968-00161	1	PANEL, FRONT	28480	03968-00161
24	2360-0276		SCREW-MACH 6-32 .375-IN-LG TR-HD-PHL	28480	2360-0276
25	03968-40011	1	FOOT	28480	03968-40011
26	3050-0010	1	WASHER-FL MTLC NO. 6 .147-IN-ID	28480	3050-0010
27	2190-0105		WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0105
28	2360-0203		SCREW-MACH 6-32 .625-IN-LG PAN-HD-POZI	28480	2360-0203
	2360-0203	2	SCREW-MACH 6-32 .625-IN-LG PAN-HD-POZI	28480	2360-0203
29	2360-0205	1	SCREW-MACH 6-32 .75-IN-LG PAN-HD-POZI	28480	2360-0205
30	2190-0105		WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0105
31	3060-0066	2		28480	3060-0066
32	03968-40002	2	FOOT, BOTTOM	28480	03968-40002
33	03968-20141	1	FRAME, FRONT	28480	03968-20141
34	03968-20111	1	MOUNTING SWITCH	28480	03968-20111
35	03968-20161	1	RAIL, TOP LEFT (3968A)	28480	03968-20161
	03964-20161	1	RAIL, TOP LEFT (3964A)	28480	03964-20161
36	2200-0140	2	SCREW-MACH 4-40 .25-IN-LG 100 DEG	28480	2200-0140
37	2200-0061	1	SCREW-MACH 4-40 .25-IN-LG TR-HD-SLT	28480	2200-0061
38	2190-0108		WASHER-LK NM NO. 4 .115-IN-ID .226-IN-OD	28480	2190-0108
39	03968-20090	1	SPACER, FRONT	28480	03968-20090
40	2190-0315		WASHER-FL MTLC NO. 5 .13-IN-ID .25-IN-OD	28480	2190-0315
41	2190-0108		WASHER-LK NM NO. 4 .115-IN-ID .226-IN-OD	28480	2190-0108
42	2200-0149		SCREW-MACH 4-40 .625-IN-LG PAN-HD-POZI	28480	2200-0149
43	03968-20081	1	SPACER, LEFT (3968A)	28480	03968-20081
	03964-20081	1	SPACER, LEFT (3964A)	28480	03964-20081
44	03968-00300	2	BRACKET, HEAT SINK (3968A)	28480	03968-00300
	03964-00300	2	BRACKET, HEAT SINK (3964A)	28480	03964-00300
45	3050-0016	1	WASHER-FL MTLC NO. 6 .147-IN-ID	28480	3050-0016
46	2190-0105		WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0105
47	2360-0199	2	SCREW-MACH 6-32 .438-IN-LG PAN-HD-POZI	28480	2360-0199
48	2360-0195		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	28480	2360-0195
49	0590-0381	9	NUT-HEX-W/LKWR 6-32-THD .12-IN-THK	78189	511-061800-01
50	2360-0195		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	28480	2360-0195
51	2190-0105		WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0105
52	3101-2042	1	SWITCH-SL DPDT-NS STD 2A 250VAC SLDR-LUG	28480	3101-2042
53	03968-00095	1	SHIELD, POWER BRACKET	28480	03968-00095
54	3105-0084	1	CIRCUIT BREAKER 1P 1.2A 250VAC CSA	28480	3105-0084
55	03968-00054	1	PANEL, FILLER	28480	03968-00054
56	3060-0066			28480	3060-0066
57	0590-0381		NUT-HEX-W/LKWR 6-32-THD .12-IN-THK	78189	511-061800-01
58	2510-0111	1	SCREW-MACH 8-32 .75-IN-LG PAN-HD-POZI	28480	2510-0111
59	2190-0017		WASHER-LK HLCL NO. 8 .168-IN-ID	28480	2190-0017
60	3101-0530	2	SWITCH-SL DPDT-NS STD 1.5A 250VAC	0505G	11A-1451
61	03968-60042	1	TRANSFORMER, POWER, CABLE ASSEMBLY	28480	03968-60042
62	03968-00105	1	COVER, HP-IB	28480	03968-00105
63	2360-0195		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	28480	2360-0195
64	2420-0001	4	NUT-HEX-W/LKWR 6-32-THD .109-IN-THK	28480	2420-0001

Table 6-5. Main Frame Parts List (Continued)

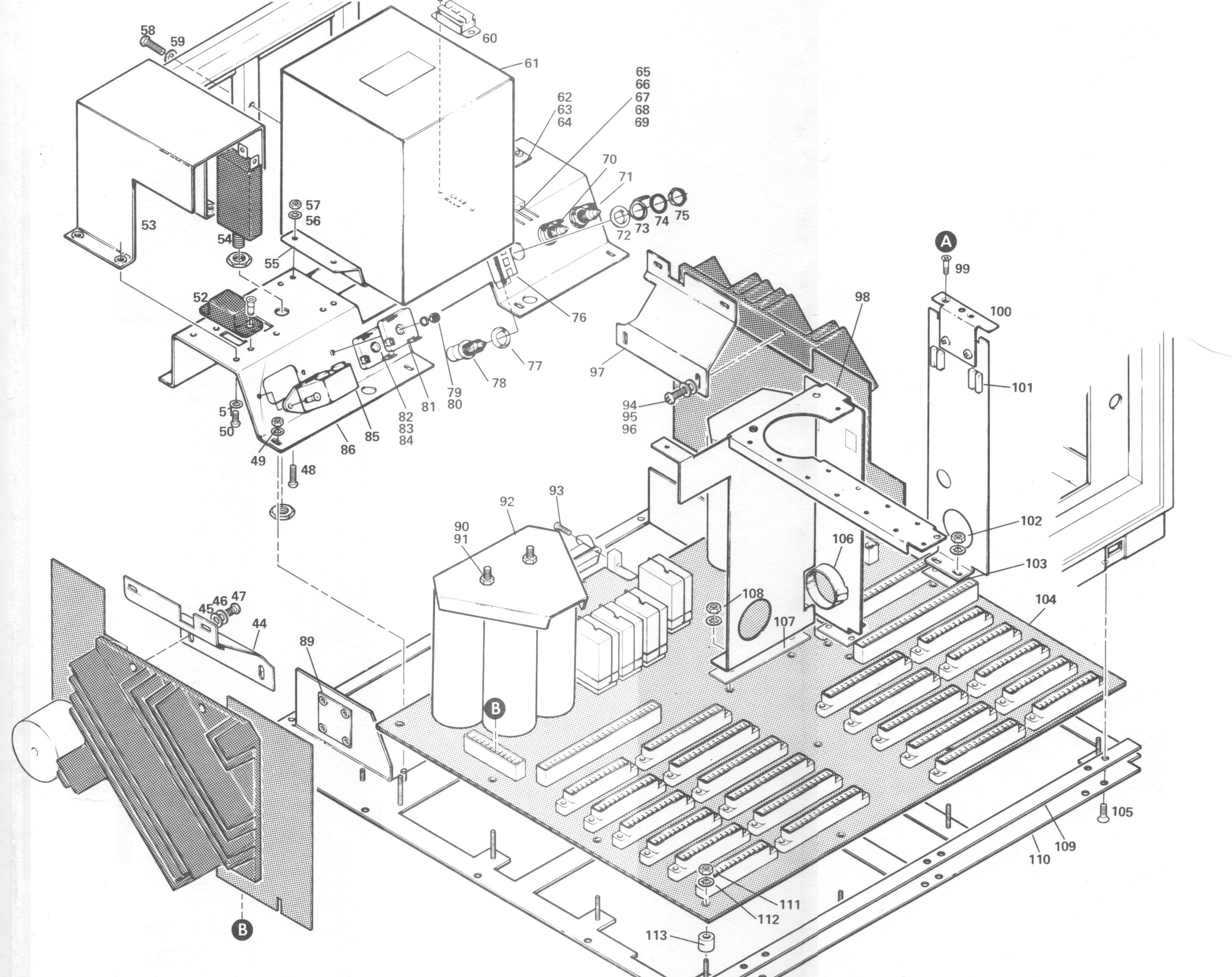
Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
65	0590-0381		NUT-HEX-W/LKWR 6-32-THD .12-IN-THK	78189	511-061800-01
66	2190-0195	1	WASHER-SHLDR NO. 6 .146-IN-ID .328-IN-OD	28480	2190-0195
67	1826-0150	1	IC 7824 V RGLTR	0223G	7824UC
68	0340-0450	1	INSULATOR-XSTR MICA	34344	14BSB52600F13
69	2360-0195		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	28480	2360-0195
70	1250-0118		CONNECTOR-RF BNC FEM SGL-HOLE-FR 50-OHM	0331F	28JR128-1
71	1250-0118		CONNECTOR-RF BNC FEM SGL-HOLE-FR 50-OHM	0331F	28JR128-1
72	5040-0702		INSULATOR:CONNECTOR	28480	5040-0702
73	0360-1190		TERMINAL-SLDR LUG PL-MTG FOR-#3/8-SCR	79963	720-.380H
74	2190-0016		WASHER-LK INTL T 3/8 IN .377-IN-ID	28480	2190-0016
75	2950-0001	1	NUT-HEX-DBL-CHAM 3/8-32-THD .094-IN-THK	28480	2950-0001
76	3101-0530		SWITCH-SL DPDT-NS STD 1.5A 250VAC	0505G	11A-1451
77	5040-0702		INSULATOR:CONNECTOR	28480	5040-0702
78	1250-0118		CONNECTOR-RF BNC FEM SGL-HOLE-FR 50-OHM	0331F	28JR128-1
79	0590-0381		NUT-HEX-W/LKWR 6-32-THD .12-IN-THK	78189	511-061800-01
80	2360-0201	2	SCREW-MACH 6-32 .5-IN-LG PAN-HD-POZI	28480	2360-0201
81	1906-0043	2	DIODE-FW BRDG 100V 12A	0203G	SDA 10257-2
82	1906-0043		DIODE-FW BRDG 100V 12A	0203G	SDA 10257-2
83	2360-0201		SCREW-MACH 6-32 .5-IN-LG PAN-HD-POZI	28480	2360-0201
84	0590-0381		NUT-HEX-W/LKWR 6-32-THD .12-IN-THK	78189	511-061800-01
85	9100-2382	1	FILTER, LINE, 1800 PF	28480	9100-2382
86	03968-00099	1	ASSEMBLY, POWER BRACKET	28480	03968-00099
87	03968-00040	1	COVER, DC SOCKET	28480	03968-00040
88	2200-0141		SCREW-MACH 4-40 .312-IN-LG PAN-HD-POZI	28480	2200-0141
89	2190-0108		WASHER-LK NM NO. 4 .115-IN-ID .226-IN-OD	28480	2190-0108
90	2740-0003	1	NUT-HEX-W/LKWR 10-32-THD .125-IN-THK	0460D	9227
91	2680-0021	1	SCREW-MACH 10-32 5-IN-LG RD-HD-SLT STL	28480	2680-0021
92	03968-00451	1	CLAMP	28480	03968-00451
93	0520-0130	1	SCREW-MACH 2-56 .375-IN-LG PAN-HD-POZI	28480	0520-0130
94	2360-0016	1	SCREW-MACH 6-32 1.25-IN-LG RD-HD-SLT	28480	2360-0016
95	2190-0105		WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0105
96	2360-0199		SCREW-MACH 6-32 .438-IN-LG PAN-HD-POZI	28480	2360-0199
97	03968-00300		BRACKET, HEAT SINK (3968A)	28480	03968-00300
	03964-00300		BRACKET, HEAT SINK (3964A)	28480	03964-00300
98	03968-00080	1	BRACKET (3968A)	28480	03968-00080
	03964-00080	1	BRACKET (3964A)	28480	03964-00080
99	2200-0140		SCREW-MACH 4-40 .25-IN-LG 100 DEG	28480	2200-0140
100	03968-00090	1	BRACKET	28480	03968-00090
101	03968-00480	1	BRACKET, CARD SUPPORT	28480	03968-00480
102	2420-0001		NUT-HEX-W/LKWR 6-32-THD .109-IN-THK	28480	2420-0001
103	03968-00470	1	INSULATOR	28480	03968-00470
104	03968-60490	1	PCA, INTERCONNECT (3968A)	28480	03968-60490
	03964-60490	1	PCA, INTERCONNECT (3964A)	28480	03964-60490
105	2360-0183	1	SCREW-MACH 6-32 .375-IN-LG 82 DEG	28480	2360-0183
106	0400-0085	1	INSULATOR-BSHG-FLG NYLON BLACK	28520	SB-1093-14
107	03968-00475	1	INSULATOR	28480	03968-00475
108	2420-0001		NUT-HEX-W/LKWR 6-32-THD .109-IN-THK	28480	2420-0001
109	03968-00125	1	SPACER, SUB-PANEL	28480	03968-00125
110	03968-00120	1	PLATE, BASE (3968A)	28480	03968-00120
	03964-00120	1	PLATE, BASE (3964A)	28480	03964-00120
111	2420-0001		NUT-HEX-W/LKWR 6-32-THD .109-IN-THK	28480	2420-0001
112	3050-0003	1	WASHER-FL NM NO. 6 .141-IN-ID .375-IN-OD	0460D	1471
113	03968-20121	1	SPACER	28480	03968-20121
114	03968-60635	1	CABLE ASSEMBLY, POWER SWITCH	28480	03968-60635
115	03968-60645	1	CABLE ASSEMBLY, POWER BRACKET	28480	03968-60645

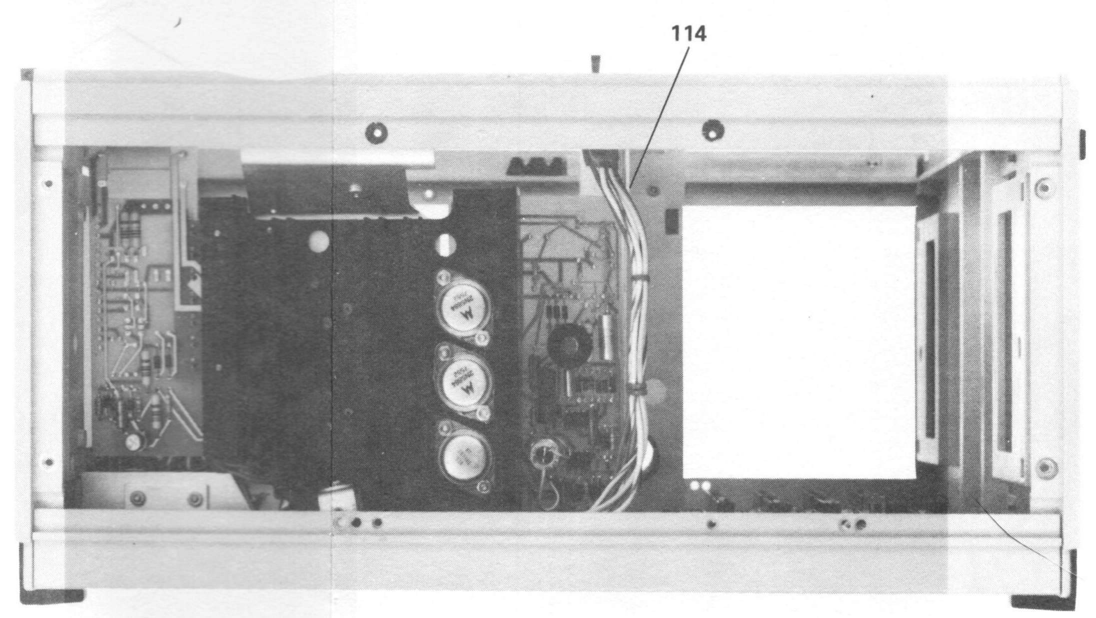


FRAME ASSEMBLY



*ASTERISK INDICATES PART NUMBER DIFFERENCE BETWEEN THE MODEL 3964A AND 3968A.





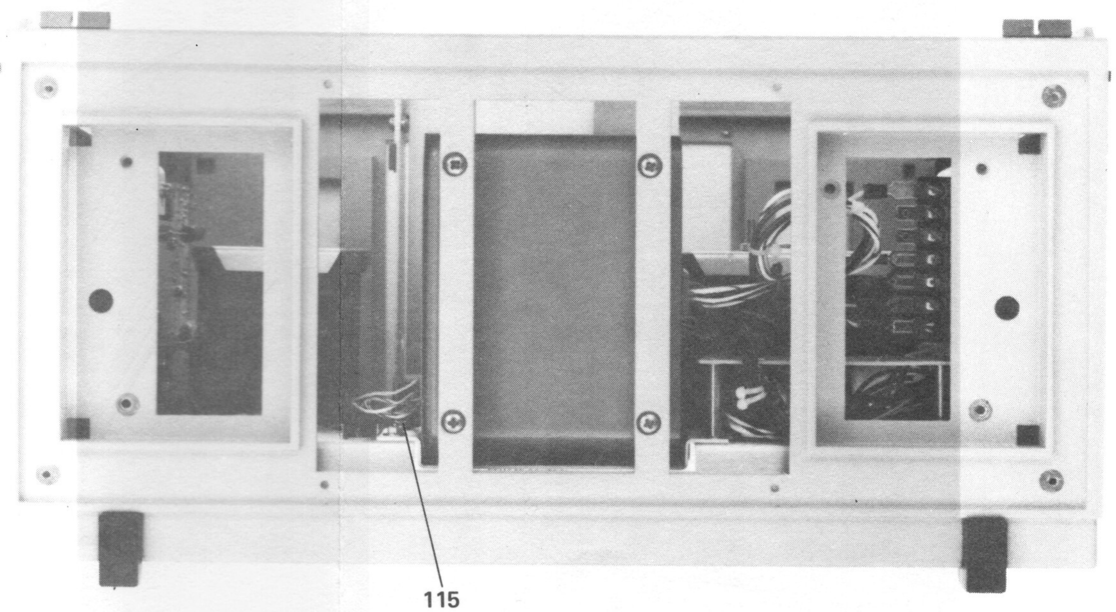


Figure 6-3. Model 3964A/3968A Main Frame, Exploded View

Table 6-6. Model 3964A/3968A Option 003–009 and Options 026–070, Parts List

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
			OPTION 003 REAR PANEL CONNECTOR		
1	0360-1190	2	TERMINAL-SLDR LUG PL-MTG FOR-#3/8-SCR	79963	720-.380H
2	1250-0118	4	CONNECTOR-RF BNC FEM SGL-HOLE-FR 50-OHM	0331F	28JR128-1
3	1251-4516	1	CONNECTOR-SGL CONT PIN .062-IN-BSC-SZ	28480	1251-4516
4	1400-0611	2	CLAMP-CABLE .1-DIA 1-WD PVC	76381	3484-1000
5	2190-0016	2	WASHER-LK INTL T 3/8 IN .377-IN-ID	28480	2190-0016
6	2360-0276	4	SCREW-MACH 6-32 .375-IN-LG TR-HD-PHL	28480	2360-0276
7	2950-0043	1	NUT-HEX-DBL-CHAM 3/8-32-THD .094-IN-THK	28480	2950-0043
8	5040-0702	3	INSULATOR:CONNECTOR	28480	5040-0702
9	03968-60001	1	CABLE, INPUT, CHANNEL 1,BROWN(3968)	28480	03968-60001
10	03968-60002	1	CABLE, INPUT, CHANNEL 2,RED(3968)	28480	03968-60002
11	03968-60003	1	CABLE, INPUT,CHANNEL 3,ORANGE (3968)	28480	03968-60003
12	03968-60004	1	CABLE, INPUT, CHANNEL 4,YELLOW (3968)	28480	03968-60004
13	03968-60005	1	CABLE, INPUT, CHANNEL 5,GREEN (3968)	28480	03968-60005
14	03968-60006	1	CABLE, INPUT, CHANNEL 6,BLUE (3968)	28480	03968-60006
15	03968-60007	1	CABLE, INPUT, CHANNEL 7,VIOLET (3968)	28480	03968-60007
16	03968-60008	1	CABLE, INPUT, CHANNEL 8,GRAY (3968)	28480	03968-60008
17	03968-60041	1	PANEL CONNECTOR ASSEMBLY (3968)	28480	03968-60041
18	03968-60105	1	CABLE ASSYS CHANNEL 1 THRU 4 (3968)	28480	03968-60105
19	03968-60106	1	CABLE ASSYS CHANNEL 5 THRU 8 (3968)	28480	03968-60106
9	03964-60001	1	CABLE, INPUT, CHANNEL 1 (3964)	28480	03964-60001
10	03964-60002	1	CABLE, INPUT, CHANNEL 2 (3964)	28480	03964-60002
13	03964-60003	1	CABLE, INPUT, CHANNEL 3 (3964)	28480	03964-60003
14	03964-60004	1	CABLE, INPUT, CHANNEL 4 (3964)	28480	03964-60004
17	03964-60040	1	PANEL CONNECTOR ASSEMBLY (3964)	28480	03964-60040
18	03964-60105	1	CABLE ASSY, CHANNEL 1 AND 2 (3964)	28480	03964-60105
19	03964-60106	1	CABLE ASSY, CHANNEL 3 AND 4 (3964)	28480	03964-60106
			OPTION 004 LOCKING KNOBS (NOT SHOWN)		
	03968-20030	1	LOCKING KNOBS (8-3968;4-3964)	28480	03968-20030
			OPT 005 METRIC SPEED IDENTIFICATION (NOT SHOWN)		
	03968-60914	1	METRIC SPEED TABS	28480	03968-60914
			OPTION 007 HP-IB INTERFACE		
1	03968-60945	2	HP-IB ASSEMBLY (REFER TO TABLE 7-16)	28480	03968-60945
2	03968-60936	1	HP-IB POWER CABLE (PART OF ITEM 1)	28480	03968-60936
3	03968-60945		HP-IB CONTROL CABLE (PART OF ITEM 1)	28480	03968-60945
4	03968-60951	1	EXTENDER CARD	28480	03968-60951
5	03968-60952	1	EXTENDER CARD	28480	03968-60952
	2190-0105	7	WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0105
	1400-0611		CLAMP-CABLE .1-DIA 1-WD PVC	76381	3484-1000
	03968-90014	1	INSTALLATION INSTRUCTION	28480	03968-90014
			OPTION 009 WHITE PAINT		
	03968-00195	1	CONTROL PANEL(3968)(ITEM 19,FIG. 6-1)	28480	03968-00195
	03964-00195	1	CONTROL PANEL(3964)(ITEM 19,FIG. 6-2)	28480	03964-00195
	03964-20652	1	HINGE, DECK (ITEM 106, FIG. 6-2)	28480	03964-20652
	03968-20682	1	HINGE, RH (ITEM 108, FIG. 6-2)	28480	03968-20682
	03968-21612	1	HINGE, COVER (ITEM 109, FIG. 6-2)	28480	03968-21612
	03968-00072	1	FILLER PANEL (NOT ILLUSTRATED)	28480	03968-00072
	03968-00644	1	PLATE, SWITCH (ITEM 225, FIG. 6-2)	28480	03968-00644
	03968-01602	1	COVER, HEAD (ITEM 107, FIG. 6-2)	28480	03968-01602
	03968-20402	1	EARS, RACK-3968 (ITEM 15, FIG. 6-3)	28480	03968-20402
	03964-20402	1	EARS, RACK-3964 (ITEM 15, FIG. 6-3)	28480	03964-20402
	03968-20612	1	DECK, TOP (ITEM 103, FIG. 6-2)	28480	03968-20612
	03968-20616	1	BUMPER, HEAD COVER (ITEM 134, FIG. 6-2)	28480	03968-20616
	03968-20632	1	COVER, DECK (ITEM 31, FIG. 6-2)	28480	03968-20632
	03968-20662	1	BLOCK PIVOT (ITEM 25, FIG. 6-2)	28480	03968-20662
	03968-60621	1	COVER ASSY, TRANSPORT (ITEM 2, FIG. 6-1)	28480	03968-60621
	03968-00142	1	RETAINING HANDLE (ITEM 4, FIG. 6-3)	28480	03968-00142
	03968-20132	1	FRAME, REAR (ITEM 10, FIG. 6-3)	28480	03968-20132
	03968-20142	1	FRAME, FRONT (ITEM 33, FIG. 6-3)	28480	03968-20142
	03968-20152	1	RAIL, TOP,RIGHT SIDE-3968(ITEM 12,FIG6-3	28480	03968-20152
	03964-20152	1	RAIL, TOP,RIGHT SIDE-3964(ITEM 12,FIG6-3	28480	03964-20152
	03968-20162	1	RAIL,TOP,LEFT SIDE-3968(ITEM 35, FIG.6-3	28480	03968-20162
	03964-20162	1	RAIL,TOP,LEFT SIDE-3964(ITEM 35, FIG.6-3	28480	03964-20162
	03968-20172	1	RAIL, BOTTOM (ITEM 13, FIG. 6-3)	28480	03968-20172
	03968-00062	1	PANEL,BLANK,FRONT (NOT ILLUSTRATED)	28480	03968-00062
			OPTION 026/027 RACK SLIDES	28480	
1			SLIDE, TILT, LEFT HAND**		
2			SCREW, PIVOT, 5/16-24**		
3			LOCKWASHER, INTERNAL TOOTH, 5/16**		
4			NUT, HEX, 5/16-24**		

Table 6-6. Model 3964A/3968A Options 003–009 and Options 026–070, Parts List (Continued)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
5			SLIDE, INTERMEDIATE, LEFT-HAND**		
6			SLIDE, STATIONARY, LEFT-HAND**		
7	13068-00020	8	SPACER, SLIDE MOUNTING, NO. 10*	28480	13068-00020
8	2680-0103	8	SCREW-MACH 10-32 .5-IN-LG PAN-HD-POZI*	28480	2680-0103
9	2190-0034	10	WASHER-LK HLCL NO. 10 .194-IN-ID*	28480	2190-0034
10	2190-0423	12	WASHER-FL MTLC NO. 10 .208-IN-ID*	28480	2190-0423
11			BRACKET, REAR SUPPORT		
12	2680-0105	4	SCREW-MACH 10-32 .625-IN-LG PAN-HD-POZI**	28480	2680-0105
13	2190-0034		WASHER-LK HLCL NO. 10 .194-IN-ID	28480	2190-0034
14	2190-0423		WASHER-FL MTLC NO. 10 .208-IN-ID	28480	2190-0423
15			NUT, LOCKING NO. 10-32**		
16	13068-00020		SPACER, SLIDING, NO. 10*	28480	13068-00020
17	2680-0103		SCREW-MACH 10-32 .5-IN-LG PAN-HD-POZI*	28480	2680-0103
18	2190-0034		WASHER-LK HLCL NO. 10 .194-IN-ID*	28480	2190-0034
19	2190-0423		WASHER-FL MTLC NO. 10 .208-IN-ID*	28480	2190-0423
20			SLIDE, TILT, RIGHT-HAND**		
21			SCREW, PIVOT, 5/16-24**		
22			LOCKWASHER, INTERNAL TOOTH, 5/16**		
23			NUT, HEX, 5/16-24**		
24			SLIDE, INTERMEDIATE, LEFT-HAND**		
25			SLIDE, STATIONARY, LEFT-HAND**		
26	13068-00020		SPACER, SLIDING, NO. 10*	28480	13068-00020
27	2680-0103		SCREW-MACH 10-32 .5-IN-LG PAN-HD-POZI*	28480	2680-0103
28	2190-0034	2	WASHER-LK HLCL NO. 10 .194-IN-ID*	28480	2190-0034
29	2190-0423		WASHER-FL MTLC NO. 10 .208-IN-ID*	28480	2190-0423
30			BRACKET, REAR SUPPORT**		
31	2680-0105		SCREW-MACH 10-32 .625-IN-LG PAN-HD-POZI	28480	2680-0105
32	2190-0034		WASHER-LK HLCL NO. 10 .194-IN-ID	28480	2190-0034
33	2190-0423		WASHER-FL MTLC NO. 10 .208-IN-ID	28480	2190-0423
34			NUT, LOCKING, NO. 10-32		
35	13068-00020		SPACER, SLIDING, NO. 10*	28480	13068-00020
36	2680-0103		SCREW-MACH 10-32 .5-IN-LG PAN-HD-POZI*	28480	2680-0103
37	2190-0034		WASHER-LK HLCL NO. 10 .194-IN-ID*	28480	2190-0034
38	2190-0423		WASHER-FL MTLC NO. 10 .208-IN-ID*	28480	2190-0423
39	13068-20020	2	SLIDE MOUNT BLOCK*	28480	13068-20020
40	13068-20020		SLIDE MOUNT BLOCK*	28480	13068-20020
41	13068-00040	2	SLIDE MOUNT BRACKET*	28480	13068-00040
42	13068-00040		SLIDE MOUNT BRACKET*	28480	13068-00040
43	03968-00400	1	PANEL, SIDE, RIGHT HAND	28480	03968-00400
44	03968-00401	1	PANEL, SIDE, LEFT HAND	28480	03968-00401
			OPT 041 SERVO REFERENCE FREQUENCY		
	03968-60531	1	CALIBRATOR/SERVO CONTROL, PCA (REFER TO TABLE 7-7 AND FIGURE 7-24)	28480	03968-60531
	03968-60710	1	CAPSTAN ASSEMBLY, (NEW) (REFER TO TABLE 6-3 AND FIGURE 6-2)	28480	03968-60710
			OPT 070 OVERLAP		
1	0510-0800	1	CLAMP-CABLE .125-DIA .5-WD ETH-CELL	0006A	ILLUMITRONICS; CLE 1/8
2	0520-0131	1	SCREW-MACH 2-56 .438-IN-LG PAN-HD-POZI	28480	0520-0131
3	0590-0985	1	NUT-SPCLY 1/4-40-THD .12-IN-THK .35-A/F	28480	0590-0985
4	2190-0105		WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0105
5	2190-0108	13	WASHER-LK NM NO. 4 .115-IN-ID .226-IN-OD	28480	2190-0108
6	2190-0427	3	WASHER-LK HLCL NO. 2 .088-IN-ID	0460D	1350
7	2190-0452	1	WASHER;RECTANGULAR #6	9598G	D6-140
8	2200-0145	1	SCREW-MACH 4-40 .438-IN-LG PAN-HD-POZI	28480	2200-0145
9	2360-0195	13	SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	28480	2360-0195
10	3030-0142	1	SCREW-SET 2-56 .125-IN-LG SMALL CUP-PT	28480	3030-0142
11	3101-1792	1	SWITCH-TGL SUBMIN SPDT NS 2A 250VAC/DC	0239B	7103-P3YZQ
12	03960-21009	1	SPACER MOUNT	28480	03960-21009
13	03960-61038	1	MOUNT ASSEMBLY, L.E.D.	28480	03960-61038
14	03960-61039	1	MOUNT, TRANSISTOR	28480	03960-61039
15	03960-61041	1	LENS HOLDER ASSEMBLY	28480	03960-61041
16	03968-00641	1	PLATE, SWITCH MARKER	28480	03968-00641
17	03968-60470	1	PCA, OVERLAP (REFER TO TABLE 7-11)	28480	03968-60470
18	03968-60640	1	OVERLAP, WIRE HARNESS	28480	03968-60640

NOTE:

ITEMS IDENTIFIED WITH * ARE USED ON OPT 027 SLIDES ONLY.

ITEMS IDENTIFIED WITH ** ARE NOT INDIVIDUALLY REPLACEABLE. TO ORDER USE CHASSIS SLIDES PART NO. 1490-0939.

Figure 6-4. Options 003, 007, 026, 027, 070, Exploded View

Table 6-7. Model 3964A/3968A Option 024, Parts List

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
1	2200-0164	4	SCREW-MACH 4-40 .188-IN-LG 82 DEG	28480	2200-0164
2	13062-20042	2	COVER, SUPPLY HUB	28480	13062-20042
3	13062-20020	1	HUB, SUPPLY	28480	13062-20020
4	2200-0166	2	SCREW-MACH 4-40 .312-IN-LG 82 DEG	28480	2200-0166
5	1480-0087	4		28480	1480-0087
6	13062-20030	1	ARM, CROSSOVER	28480	13062-20030
7	3030-0016	1	SCREW-SKT HD CAP 6-32 .5-IN-LG ALY STL	28480	3030-0016
8	13062-20090	1	BASE	28480	13062-20090
9	2200-0168	2	SCREW-MACH 4-40 .438-IN-LG 82 DEG	28480	2200-0168
10	13062-20110	1	RETAINER, BEARING	28480	13062-20110
11	13062-20080	1	IDLER, SUPPLY	28480	13062-20080
12	1410-0749	1	BEARING-ANT FRC RDL FLG .1875-BORE	28480	1410-0749
13	2200-0167	6	SCREW-MACH 4-40 .375-IN-LG 82 DEG	28480	2200-0167
14	13062-20160	1	BLOCK, EXIT	28480	13062-20160
15	13062-20190	1	INSERT, SPRING	28480	13062-20190
16	1480-0065	3	PIN-DWL .0939-DIA .375-LG STL	28480	1480-0065
17	1460-0757	1	SPRING-CPRSN .18-IN-OD .5-IN-LG SST	28480	1460-0757
18	13062-00050	1	PAD, TENSION	28480	13062-00050
19	13062-20180	1	GUIDE, EXIT	28480	13062-20180
20	1480-0332	1		28480	1480-0332
21	13062-00060	1	SPRING, BARRIER	28480	13062-00060
22	13062-20120	1	GUIDE, TAPE	28480	13062-20120
23	1460-1217	1	SPRING-EXT .187-IN-OD SST	0519A	LE-022B-00-88
24	2200-0143	1	SCREW-MACH 4-40 .375-IN-LG PAN-HD-POZI	28480	2200-0143
25	2190-0004	1	WASHER-LK INTL T NO. 6 .115-IN-ID	0G791	418-BC EVERLOCK WASHER
26	2190-0416	1	WASHER-FL MTLC NO. 4 .125-IN-ID	28480	2190-0416
27	13062-60080	1	ROLLER ASSEMBLY	28480	13062-60080
28	13062-20140	1	BUSHING, ARM	28480	13062-20140
29	13062-20150	1	PEELER, TAPE	28480	13062-20150
30	13062-20010	1	TURN TABLE	28480	13062-20010
31	13062-20100	1	COVER, BASE	28480	13062-20100
32	2200-0141	2	SCREW-MACH 4-40 .312-IN-LG PAN-HD-POZI	28480	2200-0141
33	1480-0102	1	PIN-GRV .125-DIA .375-LG STL	28480	1480-0102
34	13062-20170	1	BLOCK, TENSION	28480	13062-20170

INSTALLED TAPE LOOP ADAPTER
(OPTION 024)

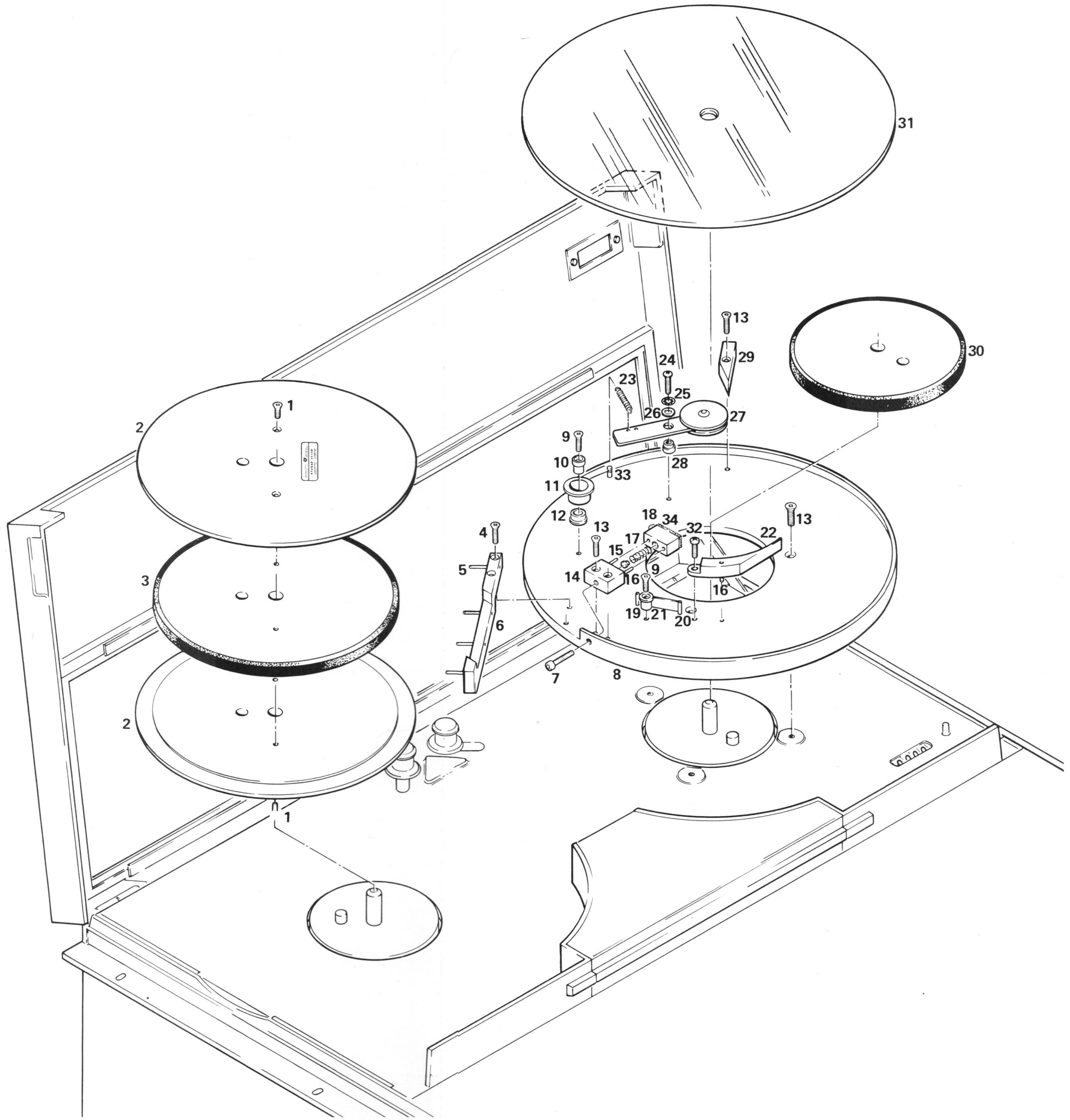


Figure 6-5. Option 024,
Exploded View

SECTION VII

ASSEMBLY DIAGRAMS AND PARTS LISTS

7-1. INTRODUCTION.

7-2. This section contains diagrams and circuit assembly part lists for the Model 3964A/3968A Tape Recorder. Included herein is an introduction to the logic symbols, schematic diagram notes, servicing block diagrams, PCA part lists, part location illustration, schematic diagrams and wiring diagrams located in this section.

7-3. LOGIC SYMBOLS.

7-4. Functional logic symbols are used in this manual where appropriate rather than the actual pack layout. A general listing and illustration of common logic used in the schematics are shown in Figure 7-1, with their function tables.

7-5. SCHEMATIC DIAGRAM SYMBOLS.

7-6. Schematic diagram symbols used in the manual are shown in Figure 7-2. For symbols not shown, refer to ANSI Standard Y32.2-1967 "Graphic Symbols For Electrical and Electronic Designs".

7-7. SERVICING BLOCK DIAGRAMS.

7-8. Servicing block diagrams for functional circuits within the Model 3964A/3968A are used to support theory of operation discussions in Section IV and troubleshooting procedures in Section V. These diagrams are located adjacent to schematic diagrams of the circuits under discussion.

7-9. PART LISTS.

7-10. Tables 7-1 through 7-17 contain the part lists for all printed circuit assemblies (PCA's) in the recorder. Each table is located adjacent to the parts location diagram and schematic diagram of the PCA. Chassis mounted parts are contained in Section VI adjacent to exploded views of the recorder assemblies.

7-11. PARTS LOCATION ILLUSTRATIONS.

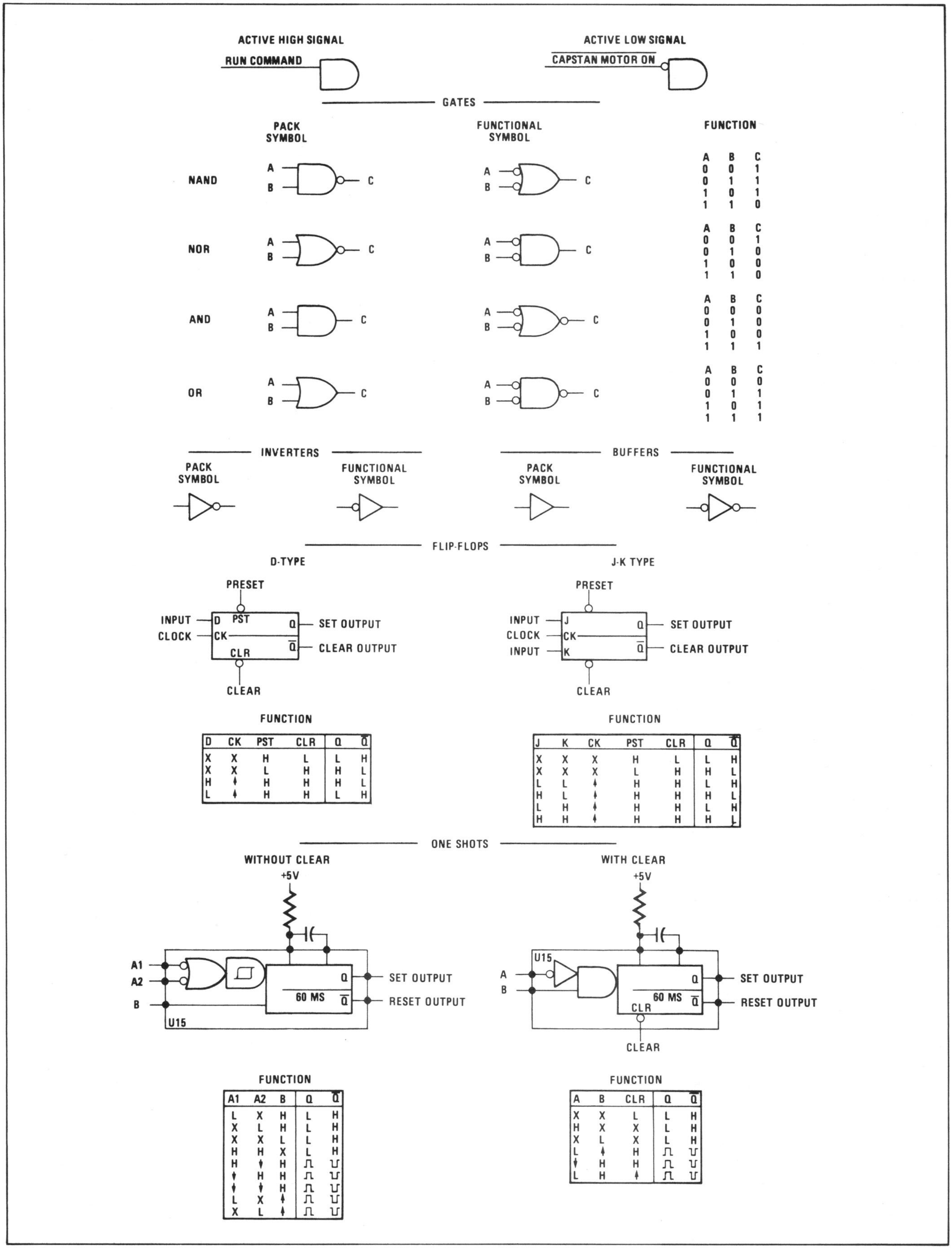
7-12. Photographs locating components on each PCA are located on the inner page of each schematic diagram. A cross-reference, grid-type matrix to facilitate locating a particular component is located between the illustration and schematic diagram.

7-13. SCHEMATIC DIAGRAMS.

7-14. Each schematic diagram contains a service sheet number, and all signal and power lines to and from the schematic are identified by an alphabetical designator and service sheet number. This type illustration is intended to facilitate referencing between schematics. See Figure 7-2 for typical line designators and service sheet numbers.

7-15. WIRING DIAGRAMS.

7-16. Figure 7-49 provides connector wiring for Interconnect PCA A24. Figure 7-51 is a cabling diagram that illustrates interconnections between Interconnect PCA A24 and chassis-mounted assemblies in the recorder. These two drawings also contain service sheet and line designation data to interconnect drawings in the manual.



FUNCTION (NAND)

A	B	C
0	0	1
0	1	1
1	0	1
1	1	0

FUNCTION (NOR)

A	B	C
0	0	1
0	1	0
1	0	0
1	1	0

FUNCTION (AND)

A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

FUNCTION (OR)

A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

FUNCTION (D-TYPE)

D	CK	PST	CLR	Q	Q̄
X	X	H	L	L	H
X	X	L	H	H	L
H	↑	H	H	H	L
L	↑	H	H	L	H

FUNCTION (J-K TYPE)

J	K	CK	PST	CLR	Q	Q̄
X	X	X	H	L	L	H
X	X	X	L	H	H	L
L	L	↑	H	H	L	H
H	L	↑	H	H	H	L
L	H	↑	H	H	L	H
H	H	↑	H	H	H	L

FUNCTION (ONE SHOT WITHOUT CLEAR)

A1	A2	B	Q	Q̄
L	X	H	L	H
X	L	H	L	H
X	X	L	L	H
H	H	X	L	H
H	↓	H	⊓	⊔
↓	H	H	⊓	⊔
↓	↓	H	⊓	⊔
L	X	↑	⊓	⊔
X	L	↑	⊓	⊔

FUNCTION (ONE SHOT WITH CLEAR)

A	B	CLR	Q	Q̄
X	X	L	L	H
H	X	X	L	H
X	L	X	L	H
L	↑	H	⊓	⊔
↓	H	H	⊓	⊔
L	H	↑	⊓	⊔

Figure 7-1. Logic Symbols

SCHEMATIC DIAGRAM NOTES

Resistance in ohms, capacitance in microfarads, inductance in microhenries unless otherwise noted.

* Asterisk denotes a factory-selected value. Value shown in typical. Part might be omitted.

Indicates a NOTE on the schematic diagram.

Tool-aided adjustment.

Manual control.

Encloses a front-panel or circuit assembly silkscreened designator.

Encloses a rear-panel silkscreened designator.

Circuit assembly borderline.

Other assembly borderline. Also used to indicate mechanical interconnection (ganging) and RF shielding.

Heavy line with arrows indicates path and direction of main signal.

Heavy dashed line with arrows indicates path and direction of main feedback.

7 Indicates cable run with seven lines.

CW Wiper moves toward CW with clockwise rotation of control (as viewed from shaft or knob).

1 Numbered Test point. Measurement aid (metal post, circuit pad, etc.) provided.

A Lettered Test point. No measurement aid provided.

( ) Encloses wire color code. Code used is the same as the resistor color code. First number identifies the base color, second number identifies the wider stripe, third number identifies the narrower stripe (e.g., (SA7) denotes white base, yellow wide stripe, violet narrow stripe).

A direct conducting connection to the earth, or a conducting connection to a structure that has a similar function (e.g., the frame of an air, sea, or land vehicle).

A conducting connection to a chassis or frame.

Common connections. All like-designated points are connected. When accompanied by a letter, indicates the type common (i.e., A = Analog, D = Digital, F = Floating).

Figure 7-2. Schematic Diagram Symbols (Page 1 of 2)

SCHEMATIC DIAGRAM NOTES (Continued)


Light Emitting Diode (LED).

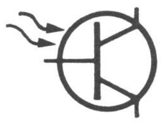
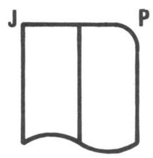


Photo-Transistor.



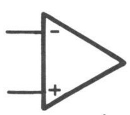
Cable and circuit assembly connectors.


Circuit assembly square-pin connectors.


Indicates circuit assembly ground.


Indicates chassis ground.

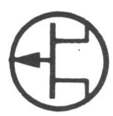

Indicates earth (safety) ground using 18 AWG wire or larger.

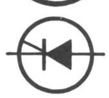


Operational Amplifier (integrated circuit).

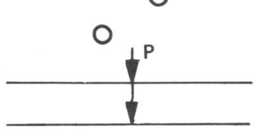

Voltage regulator (breakdown diode).


Denotes Field Effect transistor (FET) with N-type base.


Denotes FET with P-type base.


Denotes Silicon Controlled Rectifier (SCR).


Denotes spring-loaded switch.



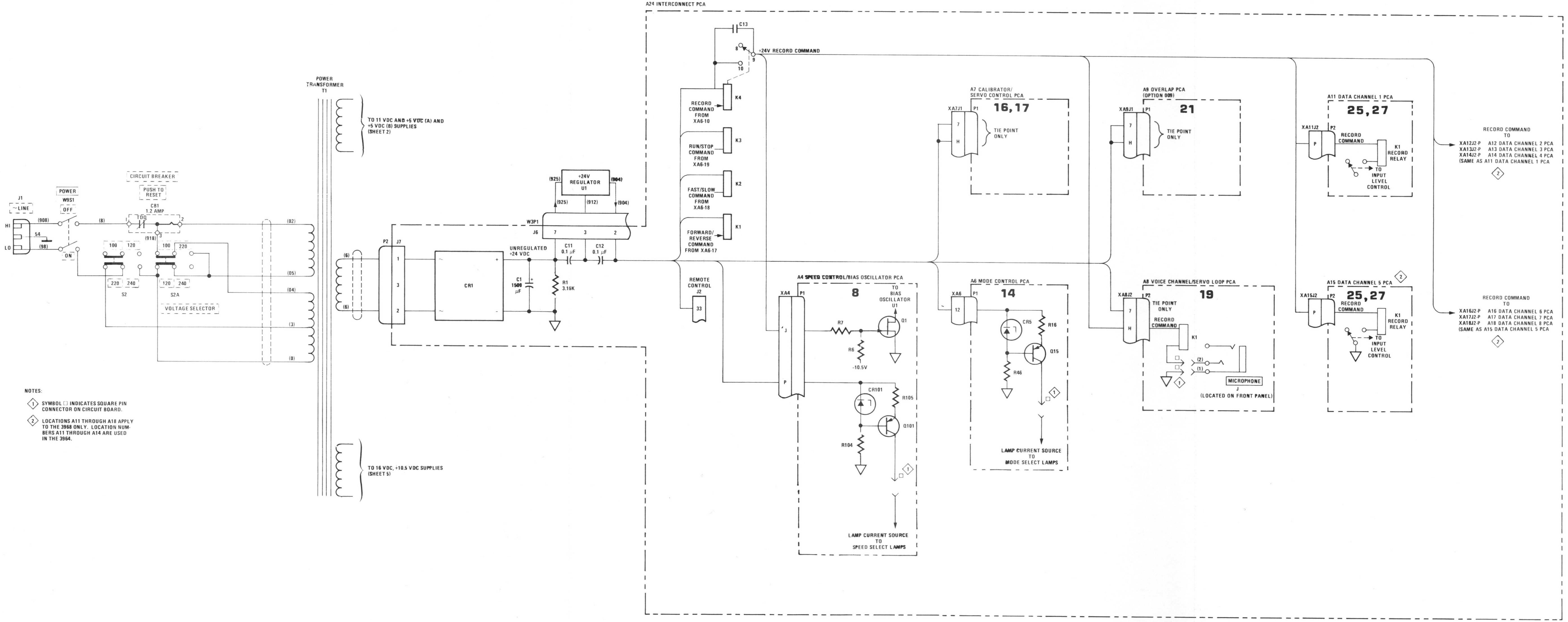
Indicates twisted pair.

4 Identifies service sheet for quick reference.

AA Signal line identification.

4 AA Combined service sheet and signal line identification.

Figure 7-2. Schematic Diagram Symbols (Page 2 of 2)



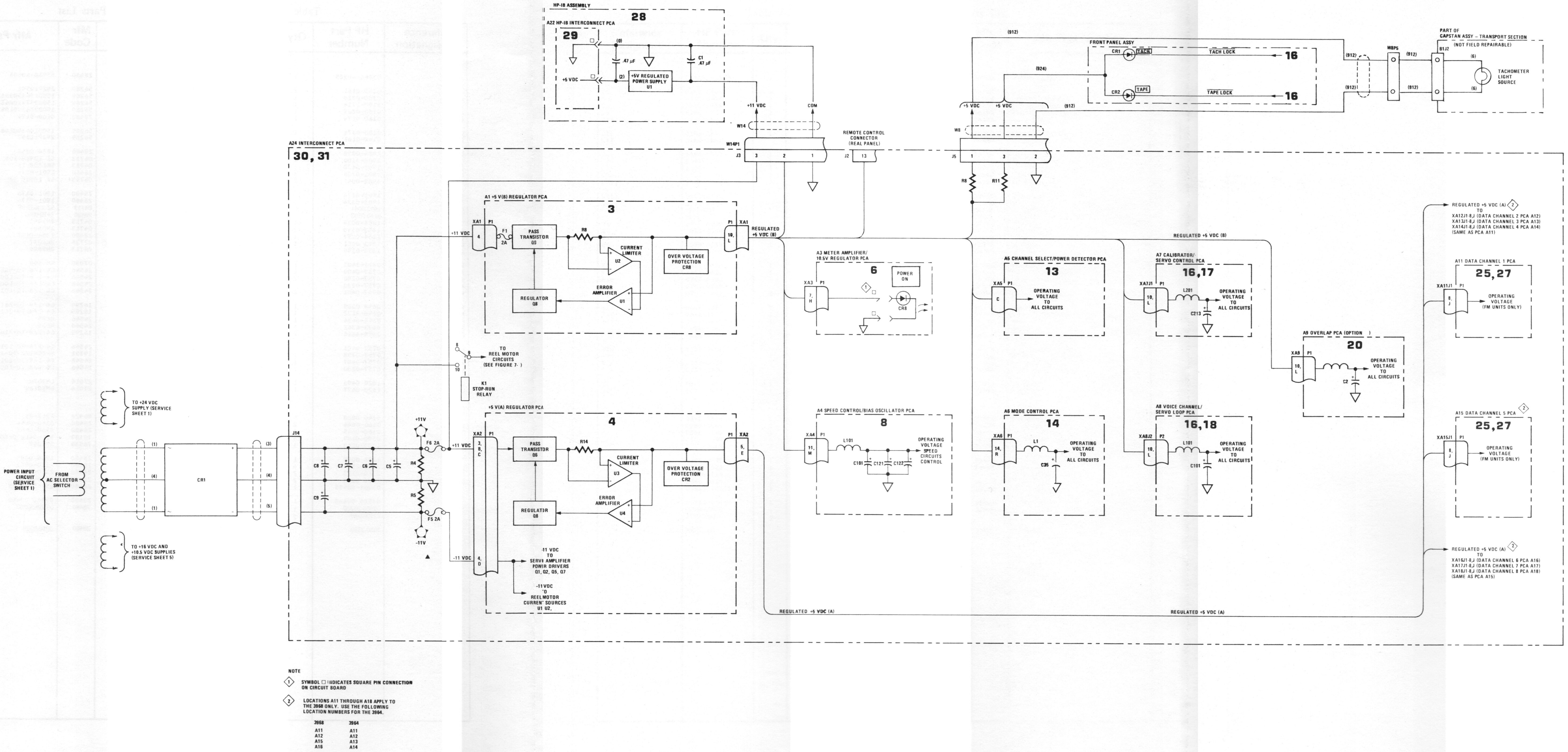
NOTES:

1. SYMBOL □ INDICATES SQUARE PIN CONNECTOR ON CIRCUIT BOARD.
2. LOCATIONS A11 THROUGH A18 APPLY TO THE 3968 ONLY. LOCATION NUMBERS A11 THROUGH A14 ARE USED IN THE 3964.

1

SERVICE SHEET

Figure 7-3. Power Input Circuit and +24 Vdc Supply, Servicing Diagram

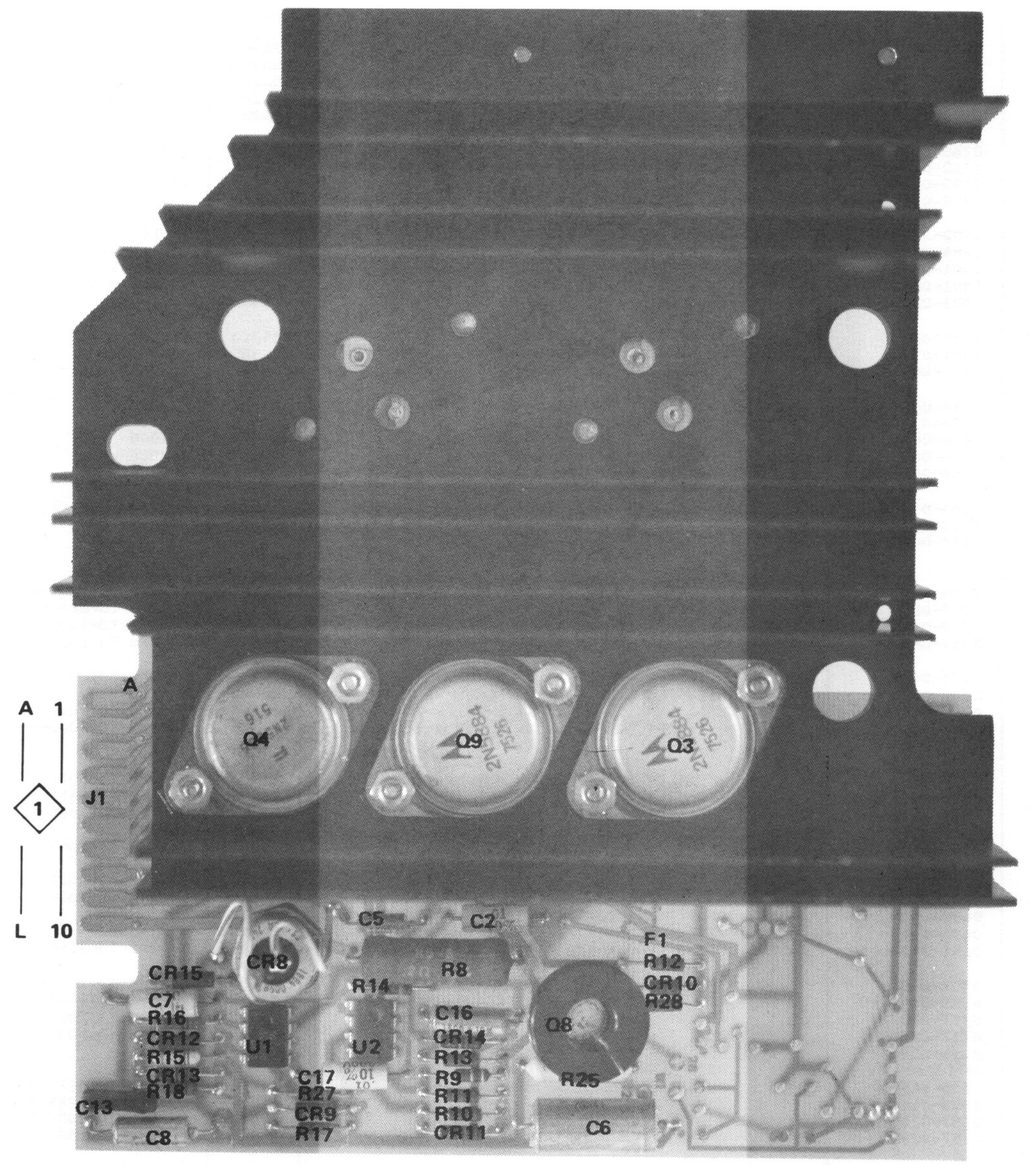


SERVICE SHEET 2

Figure 7-4. +11 Vdc, -11 Vdc, +5 Vdc(A) and +5 Vdc (B) Supplies, Servicing Diagram

Table 7-1. +5V (B) Regulator PCA A1, Parts List

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1	03968-60585	1	PCA, +5V (B) REGULATOR	28480	03968-60585
C2	0160-0161	2	CAPACITOR-FXD .01UF +-10% 200WVDC POLYE	56289	292P10392
C5	0180-0218	1	CAPACITOR-FXD .15UF+-10% 35VDC TA	56289	150D154X9035A2
C6	0180-1714	1	CAPACITOR-FXD 330UF+-10% 6VDC TA	56289	150D337X9006S2
C8	0180-0229	1	CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
C13	0160-0174	1	CAPACITOR-FXD .47UF +80-20% 25WVDC CER	28480	0160-0174
C16	0180-0374	1	CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
C17	0160-0161		CAPACITOR-FXD .01UF +-10% 200WVDC POLYE	56289	292P10392
CR8	1884-0058	1	THYRISTOR-SCR	28480	1884-0058
CR9	1902-3100	1	DIODE-ZNR 5.36V 2% DO-7 PD=.4W TC=+.004%	04713	SZ 10939-105
CR10	1901-0470	1	DIODE-HV RECT 1KV 600MA DO-41	04713	SR1358-14
CR11	1901-0376	3	DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
CR12	1902-0041	2	DIODE-ZNR 5.11V 5% DO-7 PD=.4W TC=-.009%	04713	SZ 10939-98
CR13	1901-0376		DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
CR14	1901-0376		DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
CR15	1902-0041	1	DIODE-ZNR 5.11V 5% DO-7 PD=.4W TC=-.009%	04713	SZ 10939-98
F1	2110-0303		FUSE 2A 250V SLO-BLO	28480	2110-0303
Q1	1854-0039	1	TRANSISTOR NPN 2N3053 SI TO-5 PD=1W	04713	2N3053
Q2	1853-0340	2	TRANSISTOR PNP 2N5884 SI TO-3 PD=200W	04713	2N5884
Q4	1854-0697	1	TRANSISTOR NPN 2N5886 SI TO-3 PD=200W	28480	1854-0697
Q8	1853-0051	1	TRANSISTOR PNP 2N4037 SI TO-5 PD=1W	02735	2N4037
Q9	1853-0340		TRANSISTOR PNP 2N5884 SI TO-3 PD=200W	04713	2N5884
R8	0811-3405	1	RESISTOR .2 3% 5W PW TC=0+-90	07088	KM-500
R9	0757-0400	1	RESISTOR 90.9 1% .125W F TC=0+-100	24546	C4-1/8-T0-90R9-F
R10	0757-0280	3	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
R11	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
R12	0757-0401	2	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
R13	0698-0085	1	RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
R14	0698-3132	1	RESISTOR 261 1% .125W F TC=0+-100	16299	C4-1/8-T0-2610-F
R15	0698-8634	1	RESISTOR 1.05K .1% .125W F TC=0+-25	24546	NE55
R16	0698-6362	1	RESISTOR 1K .1% .125W F TC=0+-25	24546	NE55
R17	0698-3444	1	RESISTOR 316 1% .125W F TC=0+-100	16299	C4-1/8-T0-316R-F
R18	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
R25	0757-0798	1	RESISTOR 110 1% .5W F TC=0+-100	19701	MF7C-1/2-T0-111-F
R27	0757-0407	1	RESISTOR 200 1% .125W F TC=0+-100	24546	C4-1/8-T0-201-F
R28	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
U1	1820-0493	1	IC LM 307 OP AMP	27014	LM307N
U2	1820-0477	1	IC LM 301A OP AMP	27014	LM301AN
			MISCELLANEOUS		
	0340-0828	6	INSULATOR-BSHG-FLG VULC-FIBER	86928	A363-33
	0360-0644	2	SUPPORT-BARRIER BLOCK RIGHT ANGLE	28480	0360-0644
	0360-0645	1	BARRIER BLOCK 7-TERM QUICK DISCONNECT	28480	0360-0645
	0590-0199	6	NUT-HEX-W/LKWR 4-40-THD .094-THK .25-A/F	78189	511-041800-00
	1200-0043	3	INSULATOR-XSTR TO-3 .02-THK	76530	322047
	1205-0095	1	HEAT-DISSIPATOR SGL TO-5/TO-39 PKG	28480	1205-0095
	2200-0523	6	SCREW-MACH 4-40 .562-IN-LG PAN-HD	28480	2200-0523
	2360-0115	2	SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	28480	2360-0115
	2360-0203	2	SCREW-MACH 6-32 .625-IN-LG PAN-HD-POZI	28480	2360-0203
	03968-00455	1	HEAT SINK SUPPORT	28480	03968-00455
	03968-00460	1	HEAT SINK SUPPORT	28480	03968-00460
	03968-20280	1	HEAT SINK, INVERT	28480	03968-20280
	2110-0269	2	FUSEHOLDER–CLIP TYPE .25 FUSE		
	3050-0389		WASHER, INSULATED	28480	3050-0389



NOTE:

1. PINS 1 THROUGH 10 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH L ARE ON THE REVERSE SIDE.

Figure 7-5. +5V (B) Regulator PCA A1, Parts Location

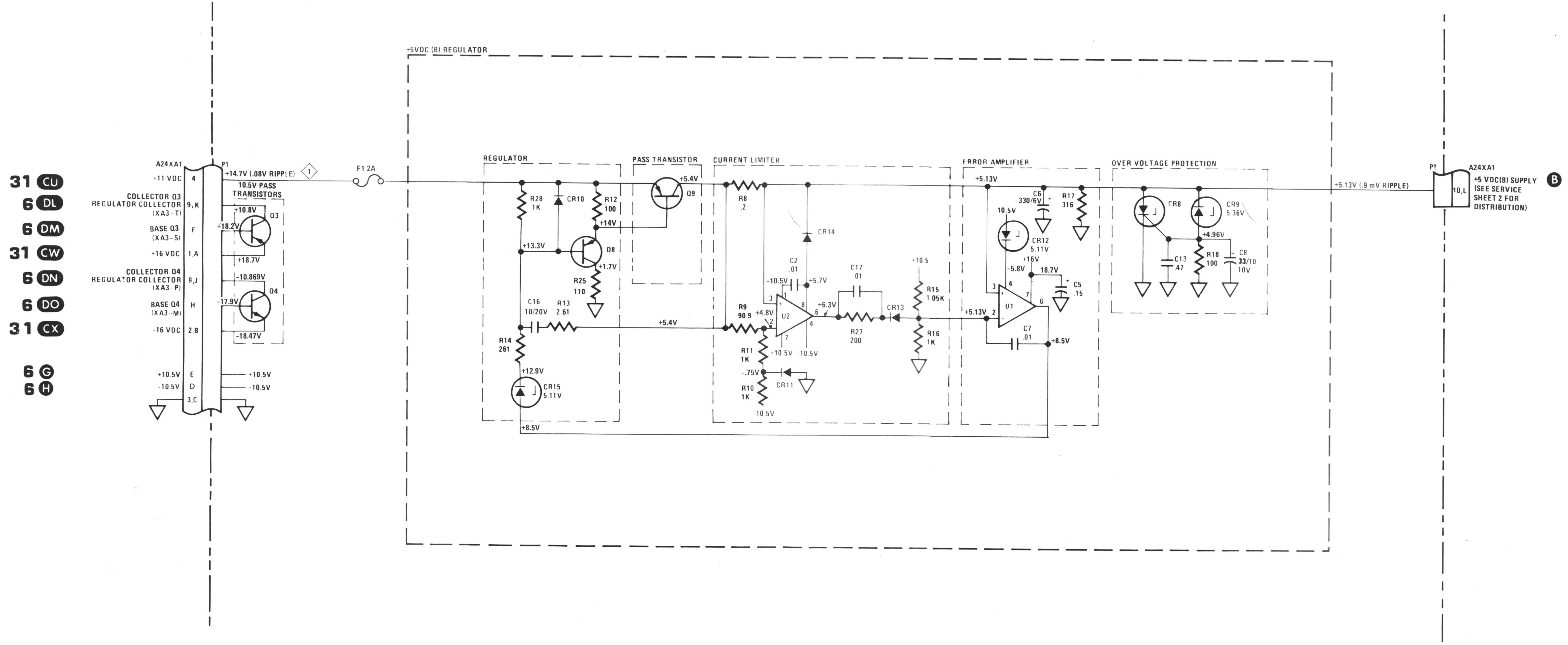


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Figure 7-6. +5 V(B) Regulator PCA A1, Schematic Diagram

Table 7-2. Capstan-Reel Motor Drivers/5V (A) Regulator PCA A2, Parts List

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A2	03968-60600	1	CAPSTAN-REEL MOTOR DRIVERS/+5V(A)REG.	28480	03968-60600
A2C1	0180-0309	2	CAPACITOR-FXD 4.7UF+-20% 10VDC TA	56289	150D475X0010A2
A2C2	0180-0309		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	56289	150D475X0010A2
A2C3	0160-2055	2	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A2C4	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A2C5	0150-0096	2	CAPACITOR-FXD .05UF +80-20% 100WVDC CER	28480	0150-0096
A2C6	0150-0096		CAPACITOR-FXD .05UF +80-20% 100WVDC CER	28480	0150-0096
A2C7	0180-0218	1	CAPACITOR-FXD .15UF+-10% 35VDC TA	56289	150D154X9035A2
A2C8	0180-1714	1	CAPACITOR-FXD 330UF+-10% 6VDC TA	56289	150D337X9006S2
A2C10	0160-0161	3	CAPACITOR-FXD .01UF +-10% 200WVDC POLYE	56289	292P10392
A2C11	0180-0229	1	CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A2C12	0160-0161		CAPACITOR-FXD .01UF +-10% 200WVDC POLYE	56289	292P10392
A2C13	0160-0174	1	CAPACITOR-FXD .47UF +80-20% 25WVDC CER	28480	0160-0174
A2C14	0180-0374	1	CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A2C15	0160-0161		CAPACITOR-FXD .01UF +-10% 200WVDC POLYE	56289	292P10392
A2CR1	1902-3100	1	DIODE-ZNR 5.36V 2% DO-7 PD=.4W TC=+.004%	04713	SZ 10939-105
A2CR2	1884-0058	1	THYRISTOR-SCR	28480	1884-0058
A2CR3	1901-0376	3	DIODE-GEN PRP 35V 50NA DO-7	28480	1901-0376
A2CR4	1902-0041	2	DIODE-ZNR 5.11V 5% DO-7 PD=.4W TC=-.009%	04713	SZ 10939-98
A2CR5	1901-0376		DIODE-GEN PRP 35V 50NA DO-7	28480	1901-0376
A2CR6	1901-0470	1	DIODE-HV RECT 1KV 600NA DO-41	04713	SR1358-14
A2CR7	1901-0376		DIODE-GEN PRP 35V 50NA DO-7	28480	1901-0376
A2CR8	1902-0041		DIODE-ZNR 5.11V 5% DO-7 PD=.4W TC=-.009%	04713	SZ 10939-98
A2Q1	1854-0618	3	TRANSISTOR NPN SI DARL TO-3 PD=150W	04713	MJ3000
A2Q2	1853-0387	1	TRANSISTOR PNP SI DARL TO-3 PD=150W	28480	1853-0387
A2Q3	1854-0618		TRANSISTOR NPN SI DARL TO-3 PD=150W	04713	MJ3000
A2Q4	1854-0618		TRANSISTOR NPN SI DARL TO-3 PD=150W	04713	MJ3000
A2Q5	1854-0039	1	TRANSISTOR NPN 2N3053 SI TO-5 PD=1W	04713	2N3053
A2Q6	1853-0340	1	TRANSISTOR PNP 2N5884 SI TO-3 PD=200W	04713	2N5884
A2Q7	1853-0051	2	TRANSISTOR PNP 2N4037 SI TO-5 PD=1W	02735	2N4037
A2Q8	1853-0051		TRANSISTOR PNP 2N4037 SI TO-5 PD=1W	02735	2N4037
A2R2	0698-4002	1	RESISTOR 5K 1% .125W F TC=0+-100	16299	C4-1/8-T0-5001-F
A2R3	0757-0276	1	RESISTOR 61.9 1% .125W F TC=0+-100	24546	C4-1/8-T0-61R9-F
A2R4	0757-0403	1	RESISTOR 121 1% .125W F TC=0+-100	24546	C4-1/8-T0-121R-F
A2R5	0757-0401	4	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R6	0757-0449	2	RESISTOR 20K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2002-F
A2R7	0812-0045	2	RESISTOR .15 5% 3W PW TC=0+-90	07088	KM-300
A2R8	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R9	0757-0449		RESISTOR 20K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2002-F
A2R10	0812-0045		RESISTOR .15 5% 3W PW TC=0+-90	07088	KM-300
A2R11	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R12	0698-0085	1	RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
A2R13	0698-3132	1	RESISTOR 261 1% .125W F TC=0+-100	16299	C4-1/8-T0-2610-F
A2R14	0811-3405	1	RESISTOR .2 3% 5W PW TC=0+-90	07088	KM-500
A2R15	0757-0400	1	RESISTOR 90.9 1% .125W F TC=0+-100	24546	C4-1/8-T0-90R9-F
A2R16	0757-0280	5	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R17	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R18	0698-8634	1	RESISTOR 1.05K .1% .125W F TC=0+-25	24546	NE55
A2R19	0698-6362	1	RESISTOR 1K .1% .125W F TC=0+-25	24546	NE55
A2R20	0698-3444	1	RESISTOR 316 1% .125W F TC=0+-100	16299	C4-1/8-T0-316R-F
A2R21	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R22	0757-0798	1	RESISTOR 110 1% .5W F TC=0+-100	19701	MF7C-1/2-T0-111-F
A2R23	0757-0407	1	RESISTOR 200 1% .125W F TC=0+-100	24546	C4-1/8-T0-201-F
A2R24	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R28	0815-0044	1	RESISTOR 25 3% 7W PW TC=0+-20	07088	KM-700
A2R29	0811-3422	1	RESISTOR 17.5 3% 10W PW TC=0+-20	01686	T10-78
A2R31	0698-3447	2	RESISTOR 422 1% .125W F TC=0+-100	16299	C4-1/8-T0-422R-F
A2R32	0698-3447		RESISTOR 422 1% .125W F TC=0+-100	16299	C4-1/8-T0-422R-F
A2R33	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R34	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2U1	1820-0493	3	IC LM 307 OP AMP	27014	LM307N
A2U2	1820-0493		IC LM 307 OP AMP	27014	LM307N
A2U3	1820-0477	1	IC LM 301A OP AMP	27014	LM301AN
A2U4	1820-0493		IC LM 307 OP AMP	27014	LM307N
			A2 MISCELLANEOUS		
	0340-0828	10	INSULATOR-BSHG-FLG VULC-FIBER	86928	A363-33
	0590-0199	10	NUT-HEX-W/LKWR 4-40-THD .094-THK .25-A/F	78189	511-041800-00
	1200-0043	5	INSULATOR-XSTR TO-3 .02-THK	76530	322047
	1205-0095	1	HEAT-DISSIPATOR SGL TO-5/TO-39 PKG	28480	1205-0095
	2190-0027	2	WASHER-LK INTL T NO.-1/4 .256-IN-ID	78189	1914-00

Table 7-2. Capstan-Reel Motor Drivers/5V (A) Regulator PCA A2, Parts List (Continued)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	2200-0523	10	SCREW-MACH 4-40 .562-IN-LG PAN-HD	28480	2200-0523
	2950-0051	1	NUT-HEX-DBL-CHAM 1/4-28-THD .094-THK	28480	2950-0051
	6040-0201	1	GREASE:SILICONE	71984	DC-4
	8150-1849	1	WIRE 20AWG W/Y/GY 300V PVC 7X28 80C	28480	8150-1849
	8150-1852	1	WIRE 20AWG W/G/GY 300V PVC 7X28 80C	28480	8150-1852
	03968-20300	1	HEAT SINK, REGULATOR	28480	03968-20300

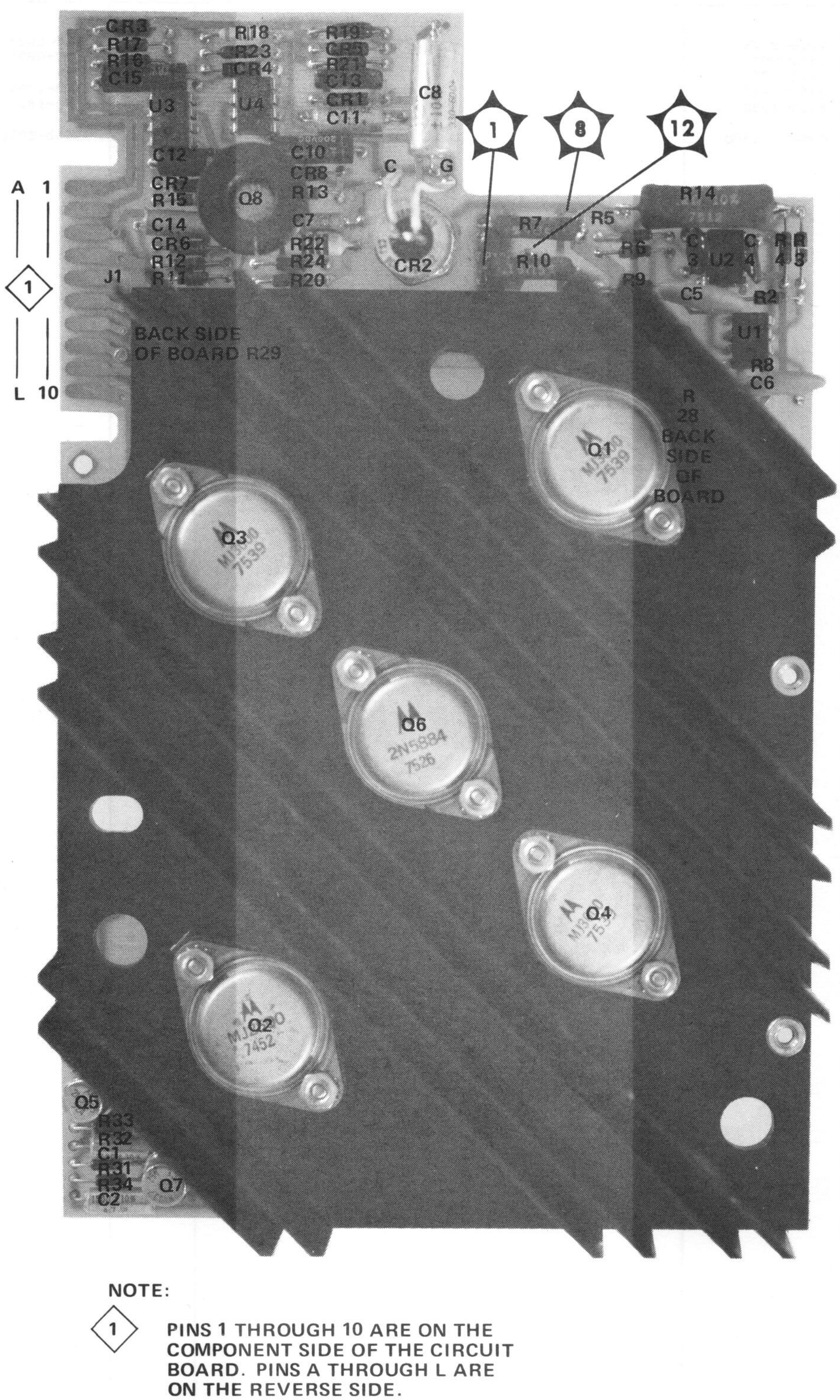
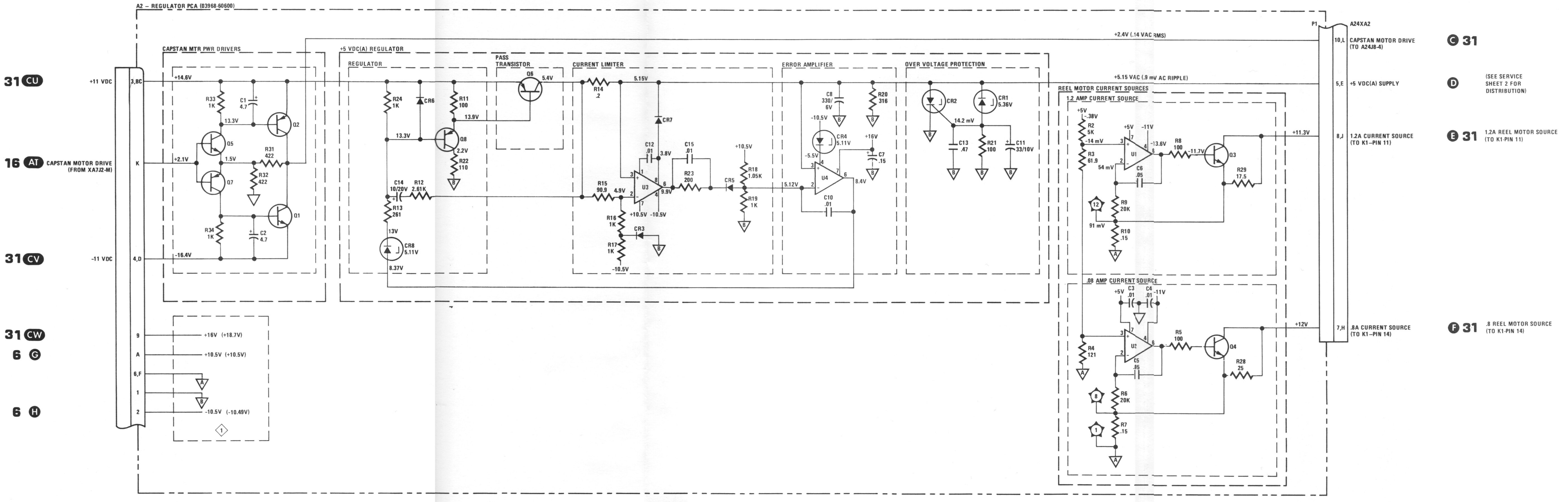


Figure 7-7. Motor Drivers/ + 5V (A) Regulator PCA A2, Parts Location



NOTES:

1. VOLTAGE MEASUREMENTS OBTAINED WITH THE SOURCE AC VOLTAGE SET AT 120 VAC.

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Figure 7-8. Motor Drivers/+5 V(A) Regulator PCA A2, Schematic Diagram

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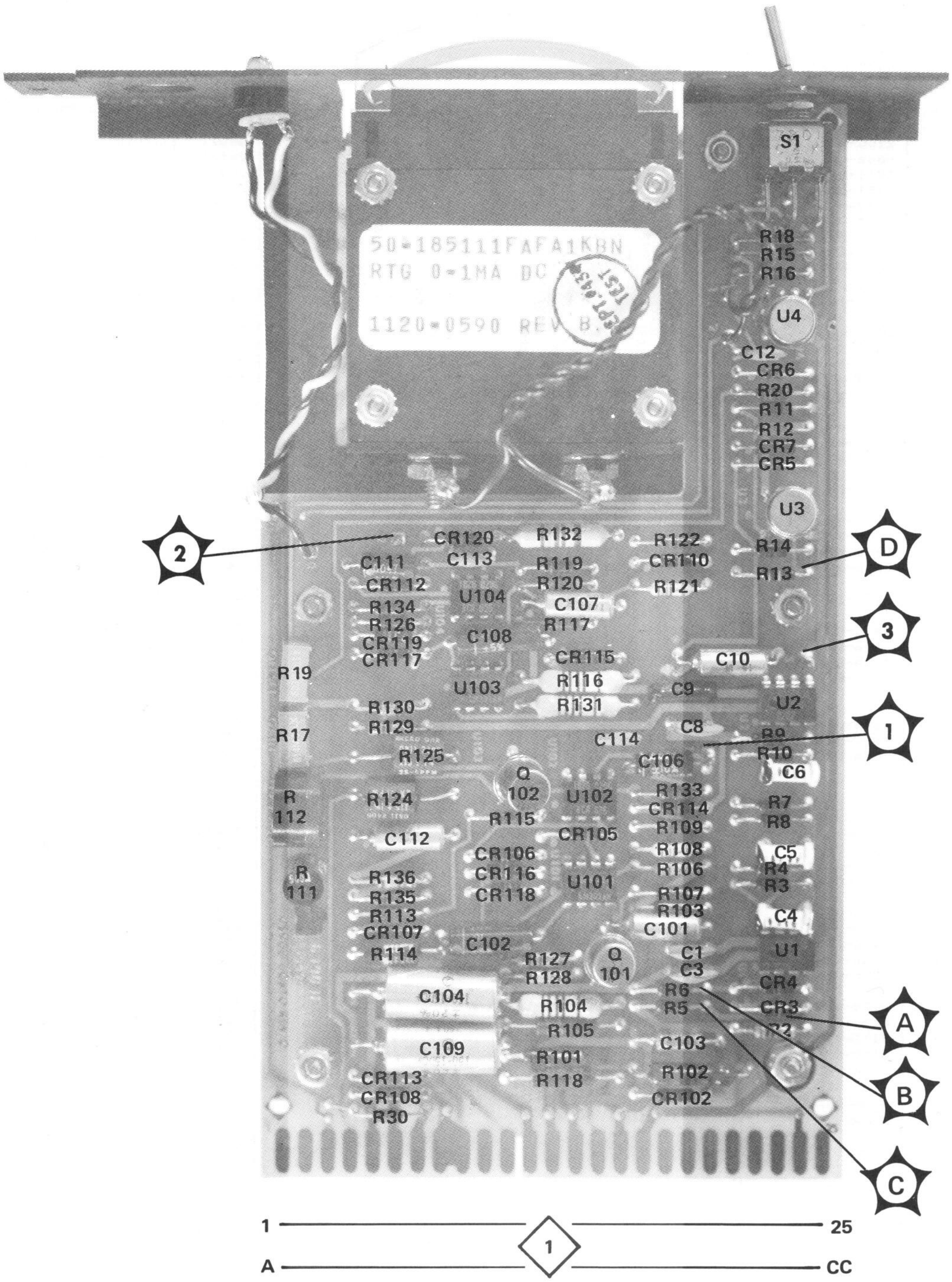
Figure 7-9. +16 Vdc, -16 Vdc, +10.5 Vdc and -10.5 Vdc Supplies, Servicing Diagram

Table 7-3. Meter Amplifier/10.5V Regulator PCA A3, Parts List

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A3	03968-60575	1	P.C.A METER AMPLIFIER ASSEMBLY	28480	03968-60575
C1	0150-0093	6	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
C3	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
C4	0160-2263	2	CAPACITOR-FXD 18PF +-5% 500WVDC CER	28480	0160-2263
C5	0160-2263		CAPACITOR-FXD 18PF +-5% 500WVDC CER	28480	0160-2263
C6	0160-2255	2	CAPACITOR-FXD 8.2PF +-.25PF 500WVDC CER	28480	0160-2255
C8	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
C9	0160-0174	1	CAPACITOR-FXD .47UF +80-20% 25WVDC CER	28480	0160-0174
C10	0180-1746	1	CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
C12	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
C101	0180-0374	2	CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
C102	0160-0207	2	CAPACITOR-FXD .01UF +-5% 200WVDC POLYE	56289	292P10352
C103	0180-0218	1	CAPACITOR-FXD .15UF+-10% 35VDC TA	56289	150D154X9035A2
C104	0180-1747	2	CAPACITOR-FXD 150UF+-20% 15VDC TA	56289	150D157X0015
C106	0160-0157	2	CAPACITOR-FXD 4700PF +-10% 200WVDC POLYE	56289	292P47292
C107	0180-0374		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
C108	0160-0207		CAPACITOR-FXD .01UF +-5% 200WVDC POLYE	56289	292P10352
C109	0180-1747		CAPACITOR-FXD 150UF+-20% 15VDC TA	56289	150D157X0015
C111	0160-0157		CAPACITOR-FXD 4700PF +-10% 200WVDC POLYE	56289	292P47292
C112	0180-0116	1	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
C113	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
C114	0150-0093		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0150-0093
CR3	1901-0376	9	DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
CR4	1901-0376		DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
CR5	1901-0040	2	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR6	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR7	1902-0050	1	DIODE-ZNR 8.66V 5% DO-7 PD=.4W TC=+.056%	04713	SZ 10939-164
CR8	1990-0521	1	LED-VISIBLE LUM-INT=2.2MCD IF=50MA-MAX	28480	1990-0521
CR102	1902-0041	3	DIODE-ZNR 5.11V 5% DO-7 PD=.4W TC=-.009%	04713	SZ 10939-98
CR105	1901-0376		DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
CR106	1901-0376		DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
CR107	1902-0680	1	DIODE-ZNR 1N827 6.2V 5% DO-7 PD=.25W	03877	1N827
CR108	1901-0470	2	DIODE-HV RECT 1KV 600MA DO-41	04713	SR1358-14
CR110	1901-0376		DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
CR112	1901-0376		DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
CR113	1901-0470		DIODE-HV RECT 1KV 600MA DO-41	04713	SR1358-14
CR114	1901-0376		DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
CR115	1902-0041		DIODE-ZNR 5.11V 5% DO-7 PD=.4W TC=-.009%	04713	SZ 10939-98
CR116	1902-3149	2	DIODE-ZNR 9.09V 5% DO-7 PD=.4W TC=+.057%	04713	SZ 10939-170
CR117	1902-3149		DIODE-ZNR 9.09V 5% DO-7 PD=.4W TC=+.057%	04713	SZ 10939-170
CR118	1901-0376		DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
CR119	1901-0376		DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
CR120	1902-0041		DIODE-ZNR 5.11V 5% DO-7 PD=.4W TC=-.009%	04713	SZ 10939-98
M1	1120-0590	1	METER, MILLIAMM 1.0 MA FSD 270 FS ACC	3G003	270 FS ACC
Q101	1854-0039	1	TRANSISTOR NPN 2N3053 SI TO-5 PD=1W	04713	2N3053
Q102	1853-0051	1	TRANSISTOR PNP 2N4037 SI TO-5 PD=1W	02735	2N4037
R2	0757-0465	1	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
R3	0757-0449	2	RESISTOR 20K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2002-F
R4	0757-0449		RESISTOR 20K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2002-F
R5	0757-0280	2	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
R6	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
R7	0757-0438	2	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
R8	0698-3136	1	RESISTOR 17.8K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1782-F
R9	0698-3167	1	RESISTOR 25K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2502-F
R10	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
R11	0757-0416	1	RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
R12	0757-0420	1	RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
R13	0757-0288	1	RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F
R14	0757-0466	1	RESISTOR 110K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1103-F
R15	0757-0439	1	RESISTOR 6.81K 1% .125W	19701	C4–1/8–TO–6811–F
R16	0757-0434	1	RESISTOR 3.65K 1% .125W	19701	C4–1/8–TO–3651–F
R17	2100-3352	1	RESISTOR VAR 1K 10%	73138	72–134–0
R18	0757-0442	1	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4–1/8–TO–1002–F
R19	2100-3274	1	RESISTOR VAR 10K 10%	73138	72–146–0
R20	0698-3449	1	RESISTOR 28.7K 1% .125W	19701	C4–1/8–TO–2872–F
R30	0698-3441	1	RESISTOR 215 1% .125W F TC=0+-100	16299	C4-1/8-T0-215R-F
R101	0757-0401	2	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
R102	0757-0833	1	RESISTOR 5.11K 1% .5W F TC=0+-100	19701	MF7C1/2-T0-5111-F
R103	0757-0278	2	RESISTOR 1.78K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1781-F
R104	0757-0804	2	RESISTOR 200 1% .5W F TC=0+-100	19701	MF7C-1/2-T0-201-F
R105	0811-3385	2	RESISTOR .5 3% 2.25W PW TC=0+-90	28480	0811-3385

Table 7-3. Meter Amplifier/10.5V Regulator PCA A3, Parts List (Continued)

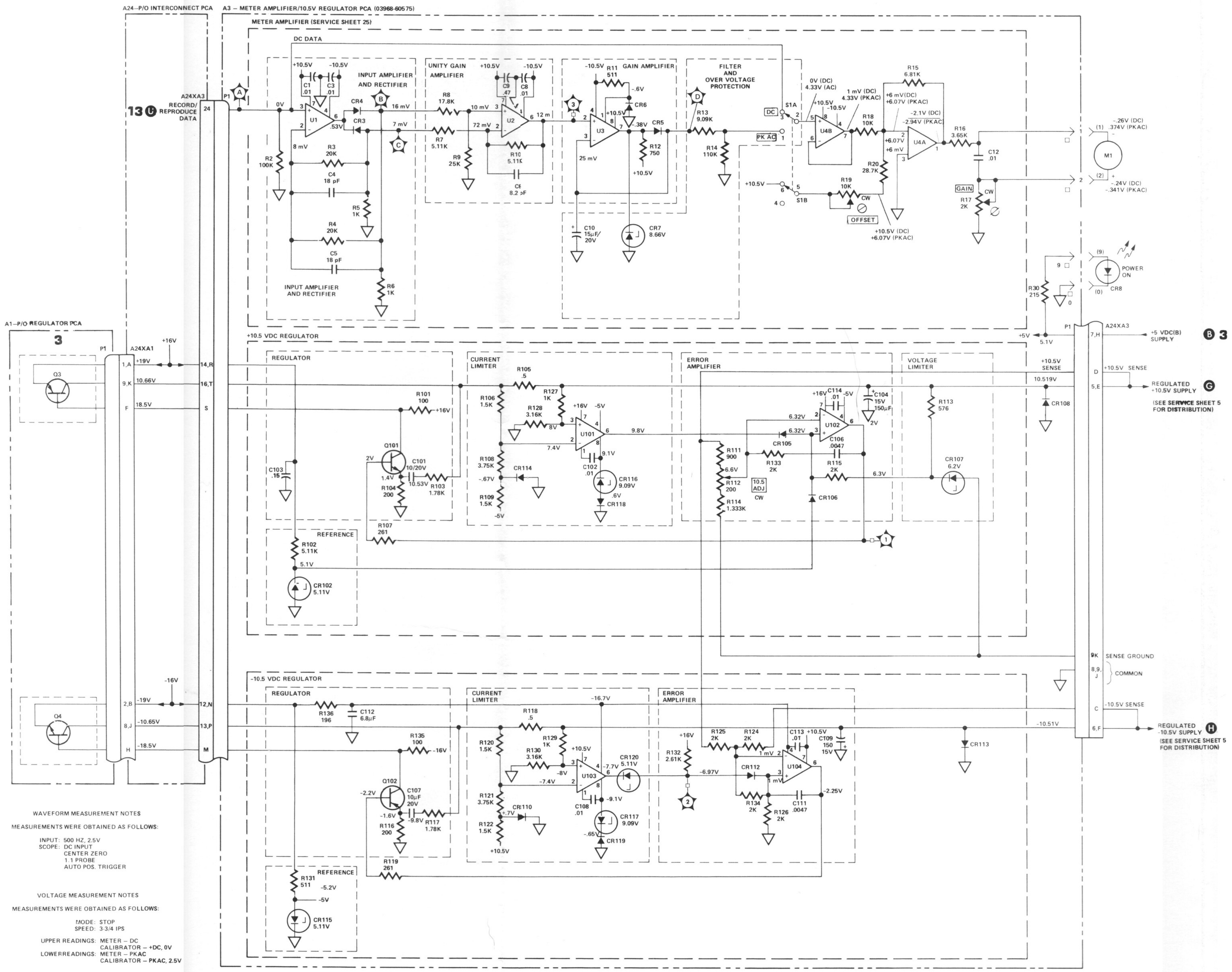
Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
R106	0698-6347	2	RESISTOR 1.5K .1% .125W F TC=0+-25	24546	NE55
R107	0698-3132	2	RESISTOR 261 1% .125W F TC=0+-100	16299	C4-1/8-T0-2610-F
R108	0698-6615	2	RESISTOR 3.75K .1% .125W F TC=0+-25	24546	NE55
R109	0757-0427	2	RESISTOR 1.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1501-F
R111	0811-3113	1	RESISTOR 900 1% .125W PWW TC=0+-5	14140	1350-1/8-901-F
R112	2100-1756	1	RESISTOR-TRMR 200 5% WW SIDE-ADJ 1-TURN	GB027	CT-106-4
R113	0698-4457	1	RESISTOR 576 1% .125W F TC=0+-100	24546	C4-1/8-T0-576R-F
R114	0811-2590	1	RESISTOR 1.333K 1% .125W PWW TC=0+-5	20940	135-1/8-C-1333R-F
R115	0757-0283	4	RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
R116	0757-0804		RESISTOR 200 1% .5W F TC=0+-100	19701	MF7C-1/2-T0-201-F
R117	0757-0278		RESISTOR 1.78K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1781-F
R118	0811-3385		RESISTOR .5 3% 2.25W PW TC=0+-90	28480	0811-3385
R119	0698-3132		RESISTOR 261 1% .125W F TC=0+-100	16299	C4-1/8-T0-2610-F
R120	0698-6347		RESISTOR 1.5K .1% .125W F TC=0+-25	24546	NE55
R121	0698-6615		RESISTOR 3.75K .1% .125W F TC=0+-25	24546	NE55
R122	0757-0427		RESISTOR 1.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1501-F
R124	0811-2406	2	RESISTOR 2K .1% .1W PWW TC=0+-5	54294	VA10-1/10-C-2001-B
R125	0811-2406		RESISTOR 2K .1% .1W PWW TC=0+-5	54294	VA10-1/10-C-2001-B
R126	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
R127	0698-6362	2	RESISTOR 1K .1% .125W F TC=0+-25	24546	NE55
R128	0698-8638	2	RESISTOR 3.16K .1% .125W F TC=0+-25	24546	NE55
R129	0698-6362		RESISTOR 1K .1% .125W F TC=0+-25	24546	NE55
R130	0698-8638		RESISTOR 3.16K .1% .125W F TC=0+-25	24546	NE55
R131	0757-0814	1	RESISTOR 511 1% .5W F TC=0+-100	19701	MF7C1/2-T0-511R-F
R132	0698-0024	1	RESISTOR 2.61K 1% .5W F TC=0+-100	24546	NA6
R133	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
R134	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
R135	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
R136	0698-3440	1	RESISTOR 196 1% .125W F TC=0+-100	16299	C4-1/8-T0-196R-F
S1	3101-1975	1	SWITCH-TGL SUBMIN DPDT NS .02A 20VAC/DC	28480	3101-1975
U1	1826-0207	2	IC LM 318 OP AMP	27014	LM318N
U2	1826-0207		IC LM 318 OP AMP	27014	LM318N
U3	1826-0026	1	IC LM 311 COMPARATOR	27014	LM311H
U4	1826-0243	1	IC MC 1558 OP AMP	27014	LM1558H
U101	1820-0477	2	IC LM 301A OP AMP	27014	LM301AN
U102	1826-0296	2	IC CA 207 OP AMP	02735	CA207E
U103	1820-0477		IC LM 301A OP AMP	27014	LM301AN
U104	1826-0296		IC CA 207 OP AMP	02735	CA207E
			MISCELLANEOUS		
	0360-0270	2	TERMINAL-LUG-SLDR 10 SCR .195/.093 ID	79963	807
	0360-1514	4	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
	0590-0836	1	NUT-HEX-SGL-CHAM 1/4-40-THD .15-THK	28480	0590-0836
	2190-0315	4	WASHER-FL MTLC NO.-5 .13-IN-ID .25-IN-OD	28480	2190-0315
	2200-0121	4	SCREW-MACH 4-40 1.125-IN-LG PAN-HD-POZI	28480	2200-0121
	2260-0009	9	NUT-HEX-W/LKWR 4-40-THD .094-THK .25-A/F	28480	2260-0009
	2740-0002	2	NUT-HEX-DBL-CHAM 10-32-THD .125-THK	28480	2740-0002
	2950-0052	1	NUT-HEX-DBL-CHAM 1/4-40-THD .062-THK	28480	2950-0052
	3050-0386	1	WASHER-SHLDR NO. 1/4 .25 IN ID .5 IN OD	72653	6528
	4330-0145	10	INSULATOR-BEAD .031-ID	28480	4330-0145
	8150-0294	1	WIRE 24AWG W 1000V PVC 7X32 105C	28480	8150-0294
	8150-0301	1	WIRE 24AWG R 1000V PVC 7X32 105C	28480	8150-0301
	8150-0302	1	WIRE 24AWG BR 1000V PVC 7X32 105C	28480	8150-0302
	8150-0303	1	WIRE 24AWG BK 1000V PVC 7X32 105C	28480	8150-0303
	03968-00248	1	SPACER, METER	28480	03968-00248
	03968-00273	1	SHIELD, METER AMPLIFIER	28480	03968-00273
	03968-20485	5	SPACER, METER AMPLIFIER	28480	03968-20485
	3050-0016	4	WASHER – FLAT .147 ID	28480	3050-0016



NOTE:

1 PINS 1 THROUGH 25 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH CC ARE ON THE REVERSE SIDE.

Figure 7-10. Meter Amplifier/10.5V Regulator PCA A3, Parts Location



WAVEFORM MEASUREMENT NOTES

MEASUREMENTS WERE OBTAINED AS FOLLOWS:

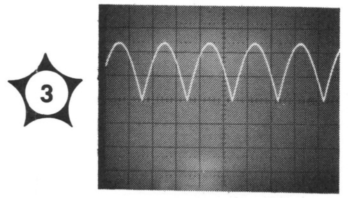
INPUT: 500 HZ, 2.5V
SCOPE: DC INPUT
CENTER ZERO
1:1 PROBE
AUTO POS. TRIGGER

VOLTAGE MEASUREMENT NOTES

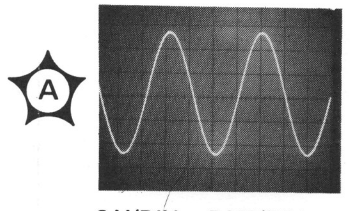
MEASUREMENTS WERE OBTAINED AS FOLLOWS:

MODE: STOP
SPEED: 3 3/4 IPS

UPPER READINGS: METER – DC
CALIBRATOR – +DC, 0V
LOWER READINGS: METER – PKAC
CALIBRATOR – PKAC, 2.5V



2 V/DIV .5 MS/DIV



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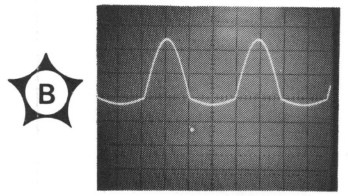
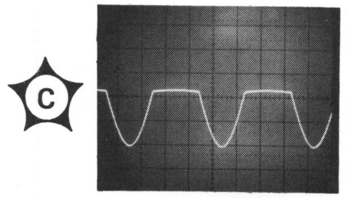
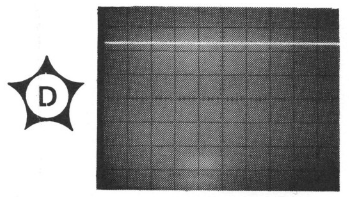


2 V/DIV .5 MS/DIV



2 V/DIV .5 MS/DIV



2 V/DIV .5 MS/DIV

6

SERVICE SHEET

Figure 7-11. Meter Amplifier/10.5V Regulator PCA A3, Schematic Diagram

7

SERVICE SHEET

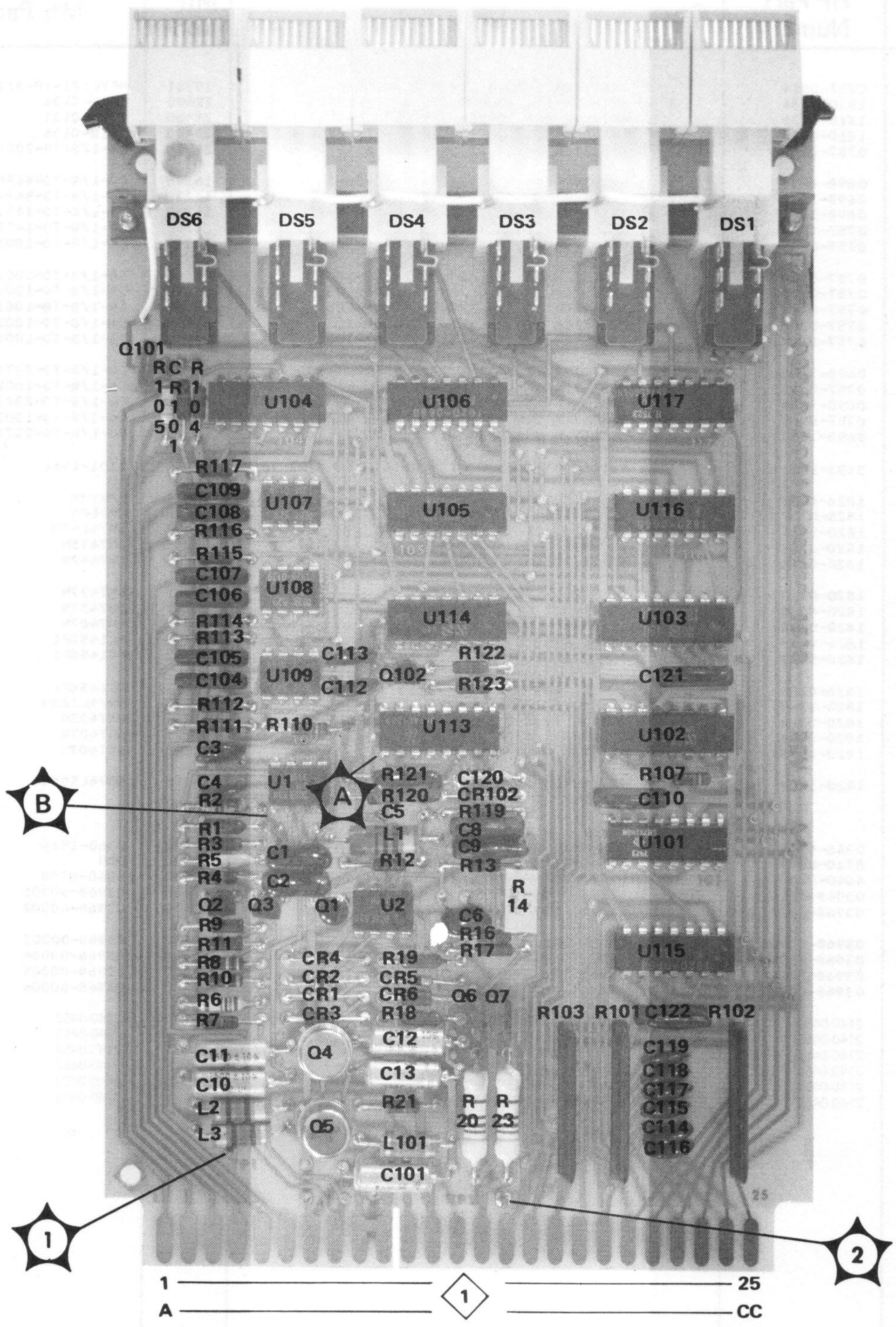
Figure 7-12. Speed Control Circuit, Servicing Diagram

Table 7-4. Tape Speed Control/Bias Oscillator PCA A4, Parts List

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A4	03968-60560	1	SPEED CONTROL/BIAS OSCILLATOR, PCA	28480	03968-60560
A4C1	0140-0225	3	CAPACITOR-FXD 300PF +-1% 300WVDC MICA	72136	DM15F301F0300WV1C
A4C2	0140-0225		CAPACITOR-FXD 300PF +-1% 300WVDC MICA	72136	DM15F301F0300WV1C
A4C3	0160-2055	10	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C4	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C5	0140-0225		CAPACITOR-FXD 300PF +-1% 300WVDC MICA	72136	DM15F301F0300WV1C
A4C6	0160-2047	1	CAPACITOR-FXD 5PF +-.5PF 500WVDC MICA	28480	0160-2047
A4C8	0160-0127	5	CAPACITOR-FXD 1UF +-20% 25WVDC CER	28480	0160-0127
A4C9	0160-0127		CAPACITOR-FXD 1UF +-20% 25WVDC CER	28480	0160-0127
A4C10	0180-0228	2	CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A4C11	0180-0228		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A4C12	0180-0116	2	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A4C13	0180-0116		CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A4C101	0180-0106	1	CAPACITOR-FXD 60UF+-20% 6VDC TA	56289	150D606X0006B2
A4C104	0150-0121	6	CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A4C105	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A4C106	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A4C107	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A4C108	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A4C109	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A4C110	0160-0127		CAPACITOR-FXD 1UF +-20% 25WVDC CER	28480	0160-0127
A4C112	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C113	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C114	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C115	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C116	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C117	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C118	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C119	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C120	0180-0197	1	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A4C121	0160-0127		CAPACITOR-FXD 1UF +-20% 25WVDC CER	28480	0160-0127
A4C122	0160-0127		CAPACITOR-FXD 1UF +-20% 25WVDC CER	28480	0160-0127
A4CR1	1901-0040	5	DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A4CR2	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A4CR3	1902-0555	2	DIODE-ZNR 13V 5% DO-15 PD=1W TC=+.06%	28480	1902-0555
A4CR4	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A4CR5	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A4CR6	1902-0555		DIODE-ZNR 13V 5% DO-15 PD=1W TC=+.06%	28480	1902-0555
A4CR101	1902-0126	1	DIODE-ZNR 2.61V 5% DO-7 PD=.4W TC=-.073%	04713	SZ 10939-14
A4CR102	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A4L1	9140-0137	1	COIL-FXD MOLDED RF CHOKE 1MH 5%	24226	19/104
A4L2	9100-1620	2	COIL-FXD MOLDED RF CHOKE 15UH 10%	24226	15/152
A4L3	9100-1620		COIL-FXD MOLDED RF CHOKE 15UH 10%	24226	15/152
A4L101	9100-1618	1	COIL-FXD MOLDED RF CHOKE 5.6UH 10%	24226	15/561
A4Q1	1855-0223	1	TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
A4Q2	1854-0215	1	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A4Q3	1853-0036	1	TRANSISTOR PNP SIL PD=310MW FT=2507HZ	04713	SPS-3612
A4Q4	1854-0637	1	TRANSISTOR NPN 2N2219A SI TO-5 PD=800MW	28480	1854-0637
A4Q5	1853-0314	1	TRANSISTOR PNP 2N2905A SI TO-5 PD=600MW	04713	2N2905A
A4Q6	1854-0300	1	TRANSISTOR NPN SI PD=25W FT=4MHZ	28480	1854-0300
A4Q7	1853-0073	2	TRANSISTOR PNP SI PD=25W FT=3MHZ	28480	1853-0073
A4Q101	1853-0073		TRANSISTOR PNP SI PD=25W FT=3MHZ	28480	1853-0073
A4Q102	1854-0071	1	TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A4R1	0698-8629	2	RESISTOR 1.69K .1% .125W F TC=0+-25	24546	NE55
A4R2	0698-8629		RESISTOR 1.69K .1% .125W F TC=0+-25	24546	NE55
A4R3	0757-0416	1	RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A4R4	0698-3444	1	RESISTOR 316 1% .125W F TC=0+-100	16299	C4-1/8-T0-316R-F
A4R5	0757-0422	1	RESISTOR 909 1% .125W F TC=0+-100	24546	C4-1/8-T0-909R-F
A4R6	0757-0469	1	RESISTOR 150K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1503-F
A4R7	0698-3266	1	RESISTOR 237K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2373-F
A4R8	0757-0288	2	RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F
A4R9	0698-0084	2	RESISTOR 2.15K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2151-F
A4R10	0757-0288		RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F
A4R11	0698-0084		RESISTOR 2.15K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2151-F
A4R12	0698-3150	4	RESISTOR 2.37K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2371-F
A4R13	0698-3150		RESISTOR 2.37K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2371-F
A4R14	2100-3207	1	RESISTOR-TRMR 5K 10% C SIDE-ADJ 1-TRN	73138	72-145-0
A4R16	0757-0180	2	RESISTOR 31.6 1% .125W F TC=0+-100	24546	C5-1/4-T0-31R6-F
A4R17	0757-0180		RESISTOR 31.6 1% .125W F TC=0+-100	24546	C5-1/4-T0-31R6-F
A4R18	0698-3429	2	RESISTOR 19.6 1% .125W F TC=0+-100	03888	PME55-1/8-T0-19R6-F
A4R19	0698-3429		RESISTOR 19.6 1% .125W F TC=0+-100	03888	PME55-1/8-T0-19R6-F
A4R20	0757-0814	2	RESISTOR 511 1% .5W F TC=0+-100	19701	MF7C1/2-T0-511R-F
A4R21	0698-3150		RESISTOR 2.37K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2371-F

Table 7-4. Tape Speed Control/Bias Oscillator PCA A4, Parts List (Continued)

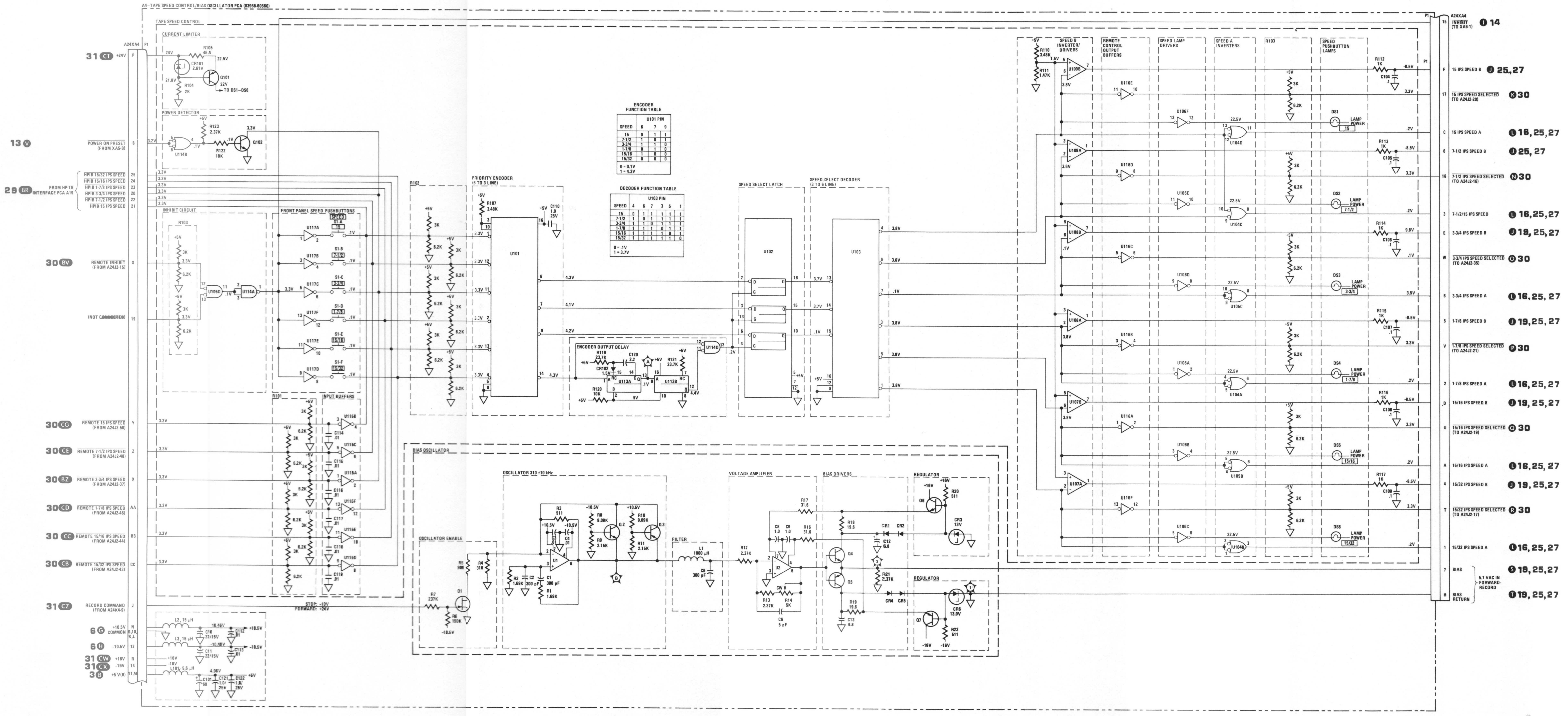
Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A4R23	0757-0814		RESISTOR 511 1% .5W F TC=0+-100	19701	MF7C1/2-T0-511R-F
A4R101	1810-0136	3	NETWORK-RES 10-PIN-SIP .1-PIN-SPCG	28480	1810-0136
A4R102	1810-0136		NETWORK-RES 10-PIN-SIP .1-PIN-SPCG	28480	1810-0136
A4R103	1810-0136		NETWORK-RES 10-PIN-SIP .1-PIN-SPCG	28480	1810-0136
A4R104	0757-0283	1	RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
A4R105	0698-4037	1	RESISTOR 46.4 1% .125W F TC=0+-100	16299	C4-1/8-T0-46R4-F
A4R107	0698-3152	2	RESISTOR 3.48K 1% .125W F TC=0+-100	16299	C4-1/8-T0-3481-F
A4R110	0698-3152		RESISTOR 3.48K 1% .125W F TC=0+-100	16299	C4-1/8-T0-3481-F
A4R111	0757-1094	1	RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A4R112	0757-0280	6	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R113	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R114	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R115	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R116	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R117	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R119	0698-3158	2	RESISTOR 23.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2372-F
A4R120	0757-0442	2	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R121	0698-3158		RESISTOR 23.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2372-F
A4R122	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R123	0698-3150		RESISTOR 2.37K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2371-F
A4S1	3101-1961	1	SWITCH-PB 6STA DPDT MOM .689 IN-CTRS .5A	28480	3101-1961
A4U1	1826-0207	2	IC LM 318 OP AMP	27014	LM318N
A4U2	1826-0207		IC LM 318 OP AMP	27014	LM318N
A4U101	1820-1473	1	IC SN74 148 N ENCODER	01295	SN74148N
A4U102	1820-0301	1	IC SN74 75 N LATCH	01295	SN7475N
A4U103	1820-0214	1	IC:TTL BCD-TO-DECIMAL DECODER	01295	SN7442N
A4U104	1820-0539	2	IC SN74 37 N BUFFER	01295	SN7437N
A4U105	1820-0539		IC SN74 37 N BUFFER	01295	SN7437N
A4U106	1820-0668	3	IC SN74 07 N BUFFER	01295	SN7407N
A4U107	1826-0139	3	IC MC 1458 OP AMP	04713	MC1458P1
A4U108	1826-0139		IC MC 1458 OP AMP	04713	MC1458P1
A4U109	1826-0139		IC MC 1458 OP AMP	04713	MC1458P1
A4U113	1820-1247	1	IC SN74L 123 N MV	01295	SN74L123N
A4U114	1820-0328	1	IC:TTL QUAD 2-INPT NOR GATE	01295	SN7402N
A4U115	1820-0668		IC SN74 07 N BUFFER	01295	SN7407N
A4U116	1820-0668		IC SN74 07 N BUFFER	01295	SN7407N
A4U117	1820-1200	1	IC SN74LS 05 N INV	01295	SN74LS05N
			A4 MISCELLANEOUS		
	0360-1514	2	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
	0510-0843	2	PIN-SPRING SPIRAL PIN TYPE .062" DIA	00000	OBD
	4040-0750	2	EXTRACTOR-PC BD RED POLYC .062-BD-THKNS	28480	4040-0750
	03968-00001	1	LABEL, PUSHBUTTON	28480	03968-00001
	03968-00002	1	LABEL, PUSHBUTTON	28480	03968-00002
	03968-00003	1	LABEL, PUSHBUTTON	28480	03968-00003
	03968-00004	1	LABEL, PUSHBUTTON	28480	03968-00004
	03968-00005	1	LABEL, PUSHBUTTON	28480	03968-00005
	03968-00006	1	LABEL, PUSHBUTTON	28480	03968-00006
A4DS1	2140-0452	6	LAMP, INCANDESCENT, 24V	28480	2140-0452
A4DS2	2140-0452		LAMP, INCANDESCENT, 24V	28480	2140-0452
A4DS3	2140-0452		LAMP, INCANDESCENT, 24V	28480	2140-0452
A4DS4	2140-0452		LAMP, INCANDESCENT, 24V	28480	2140-0452
A4DS5	2140-0452		LAMP, INCANDESCENT, 24V	28480	2140-0452
A4DS6	2140-0452		LAMP, INCANDESCENT, 24V	28480	2140-0452



NOTE:

1 PINS 1 THROUGH 25 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH CC ARE ON THE REVERSE SIDE.

Figure 7-13. Tape Speed Control/Bias Oscillator PCA A4, Parts Location



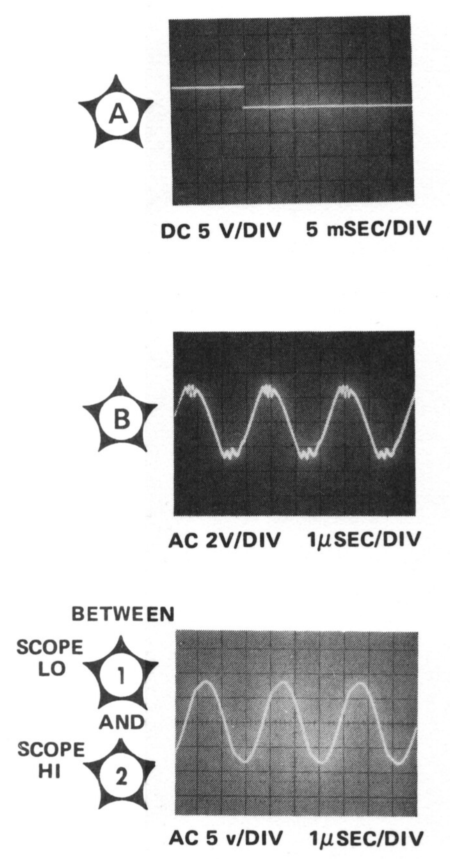


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Figure 7-14. Tape Speed Control/Bias Oscillator PCA A4, Schematic Diagram

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Figure 7-15. Mode Control Servicing Diagram (Forward, Reverse, Record and E-to-E Functions)

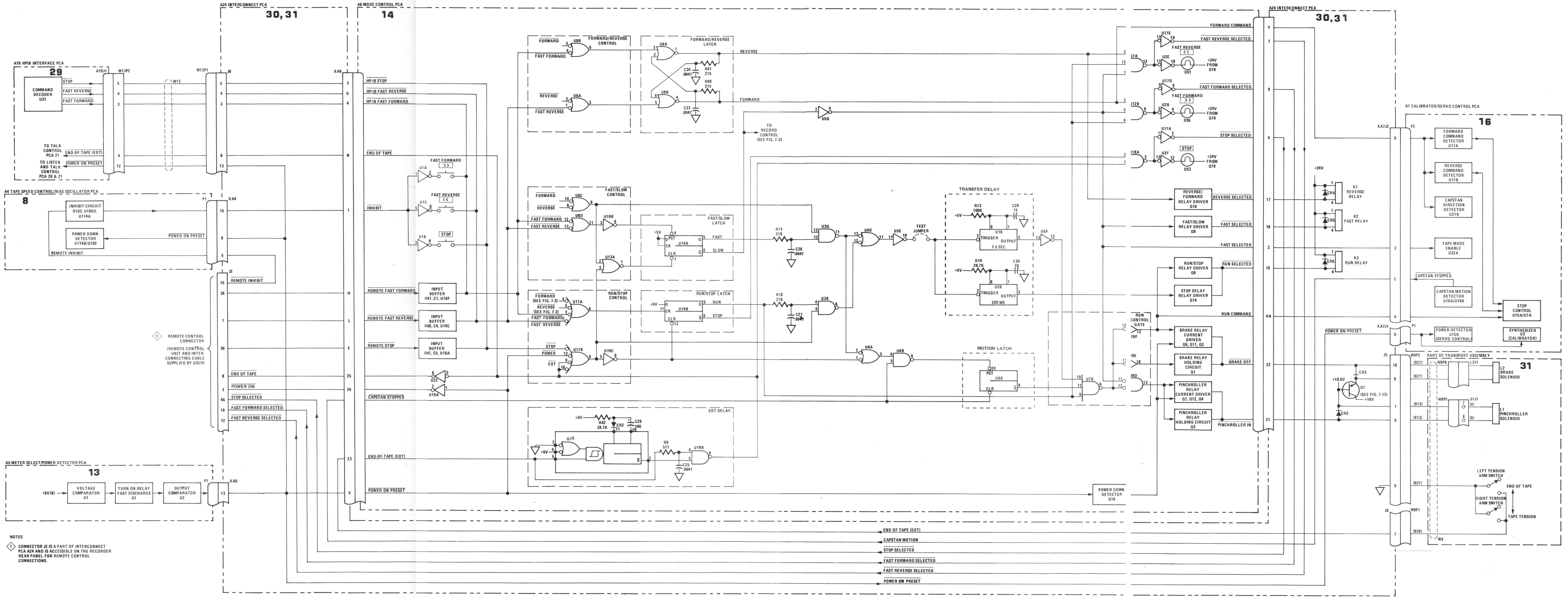

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Figure 7-16. Mode Control Servicing Diagram (Fast Modes, Stop, EOT and Power Preset Functions)

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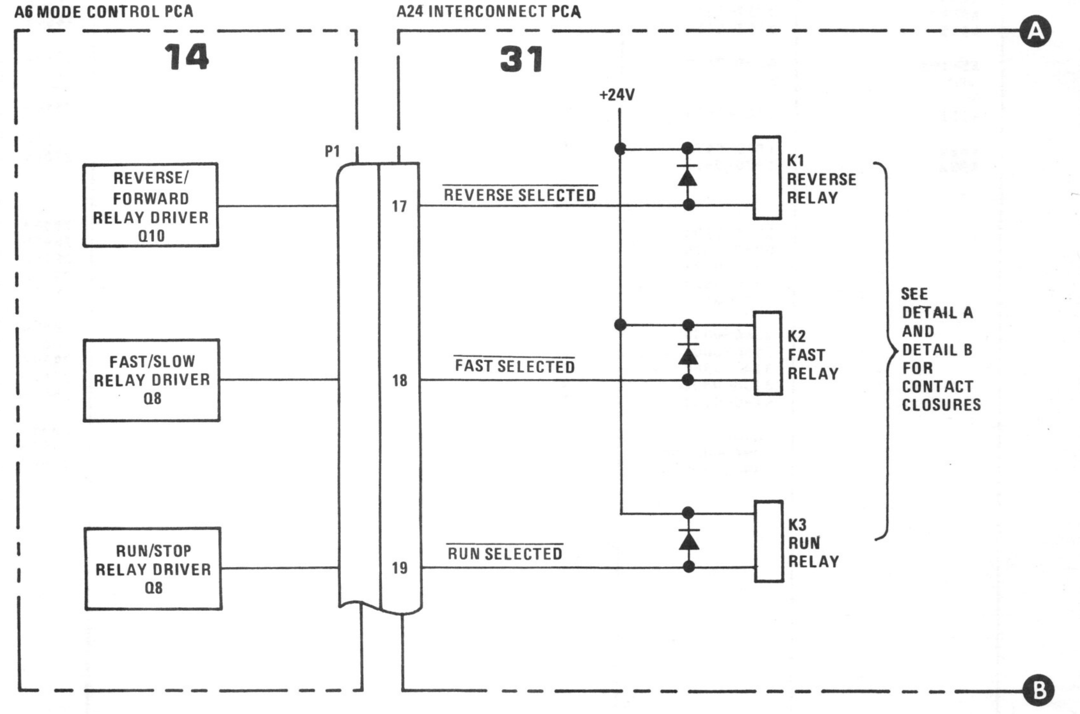
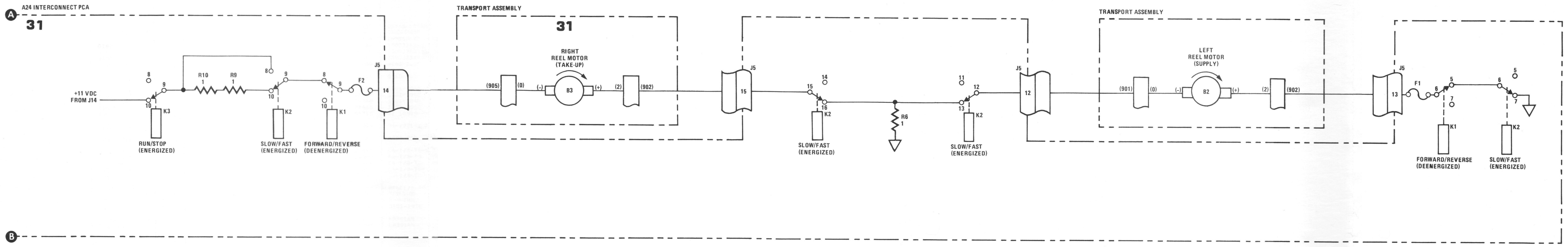
Figure 7-17. Reel Motor Servicing Diagram (Forward, Reverse Functions)



DETAIL A

FORWARD – FAST REEL MOTOR CONFIGURATION



DETAIL B

REVERSE – FAST REEL MOTOR CONFIGURATION

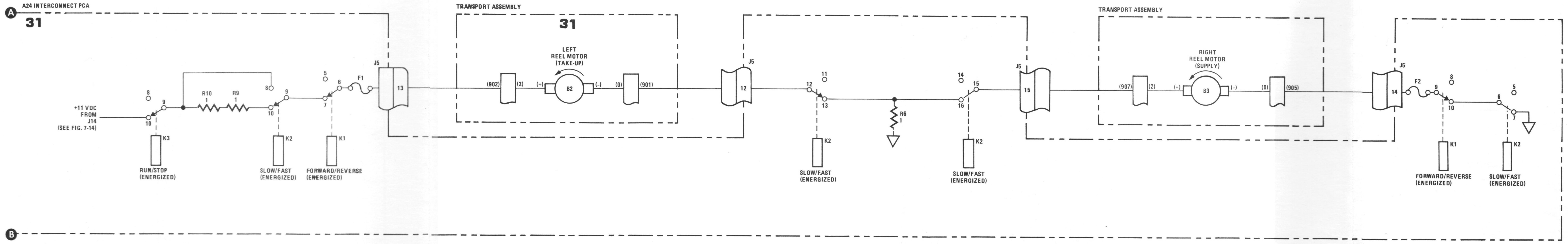


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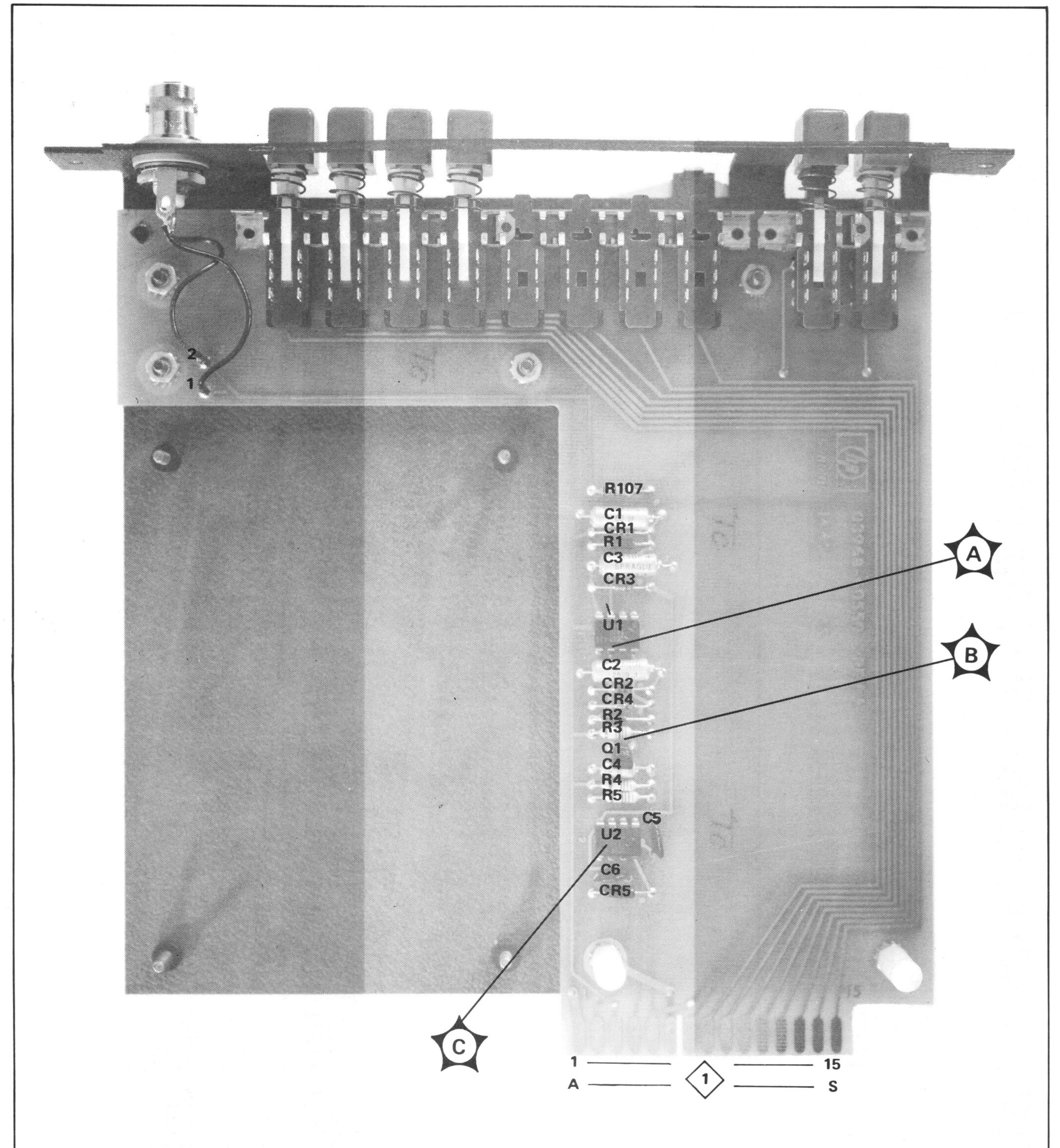
Figure 7-18. Reel Motor Servicing Diagram (Fast Forward, Fast Reverse Functions)

Table 7-5. Meter Select/Power Detector PCA A5, Parts List

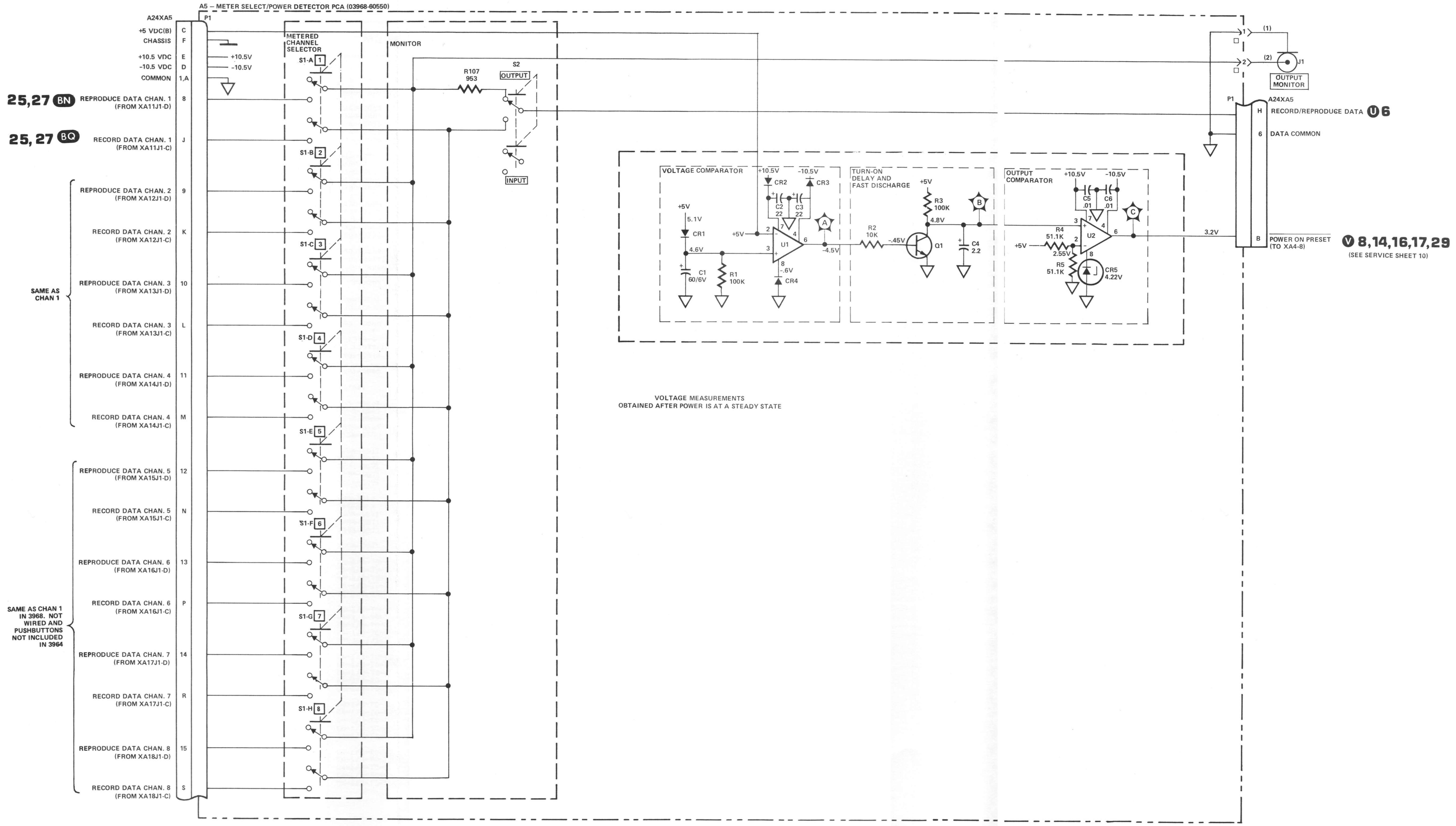
Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A5	03968-60550	1	METER SELECT/POWER DETECTOR, PCA	28480	03968-60550
A5	03964-60550	1	METER SELECT/POWER DETECTOR, PCA	28480	03964-60550
A5C1	0180-0106	1	CAPACITOR-FXD 60UF+-20% 6VDC TA	56289	150D606X0006B2
A5C2	0180-0228	2	CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A5C3	0180-0228		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A5C4	0180-0197	1	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C5	0160-2055	2	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A5C6	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A5CR1	1901-0040	4	DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A5CR2	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A5CR3	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A5CR4	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A5CR5	1902-3070	1	DIODE-ZNR 4.22V 5% DO-7 PD=.4W TC=-.038%	04713	SZ 10939-74
A5J1	1250-0118	1	CONNECTOR-RF BNC FEM SGL HOLE FR	90949	31-2221-1022
A5Q1	1854-0071	1	TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A5R1	0757-0465	2	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R2	0757-0442	1	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R3	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R4	0757-0458	2	RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A5R5	0757-0458		RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A5R107	0698-7630	1	RESISTOR 953 1% .125W F TC=0+-25	19701	MF4C1/8-T9-953R-F
A5S1	3101-2100	1	SWITCH-PB 4STA DPDT (3964A)	28480	3101-2100
A5S1	3101-2101	1	SWITCH-PB 8STA DPDT (3968A)	28480	3101-2101
A5S2	3101-1976	1	SWITCH-PB 2STA DPDT INTLH .492 IN-CTRS	28480	3101-1976
A5U1	1820-0477	2	IC LM 301A OP AMP	27014	LM301AN
A5U2	1820-0477		IC LM 301A OP AMP	27014	LM301AN
			A5 MISCELLANEOUS		
	0360-1190	1	TERMINAL-LUG-SLDR 3/8 SCR .38/.078 ID	79963	720-.380H
	0360-1514	2	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
	0362-0227	2	TERMINAL-CRP QDISC FEM 30-24AWG	28480	0362-0227
	0380-0917	6	STANDOFF-RND .125LG .115ID .250D FBR	06540	9222
	2190-0163	1	WASHER-LK INTL T NO.-3/8 .38-IN-ID	78189	1220-05
	2260-0009	6	NUT-HEX-W/LKWR 4-40-THD .094-THK .25-A/F	28480	2260-0009
	2950-0001	1	NUT-HEX-DBL-CHAM 3/8-32-THD .094-THK	12697	20/4-13
	3131-0382	10	BUTTON-PB-SW BUTTERSCOTCH GOLD; .398-IN	71590	J52312 BUTTERSCOTCH GOLD
	8150-0301	1	WIRE 24AWG R 1000V PVC 7X32 105C	28480	8150-0301
	8150-0303	1	WIRE 24AWG BK 1000V PVC 7X32 105C	28480	8150-0303
	5040-0702	2	INSULATOR:CONNECTOR	28480	5040-0702
	03968-00251	1	SHIELD, METER MARKER	28480	03968-00251
	03968-20070	2	GUIDE, BOARD	28480	03968-20070

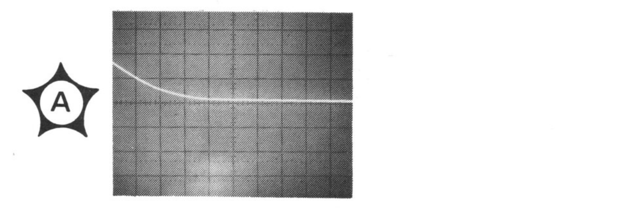


NOTE:

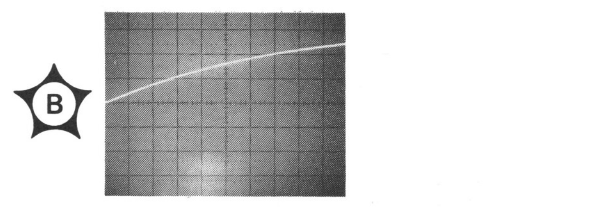
1. PINS 1 THROUGH 15 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH S ARE ON THE REVERSE SIDE.

Figure 7-19. Meter Select/Power Detector PCA A5, Parts Location (Model 3964A Illustrated)

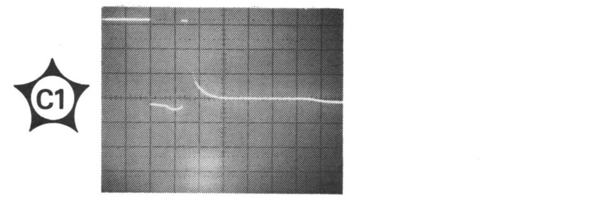




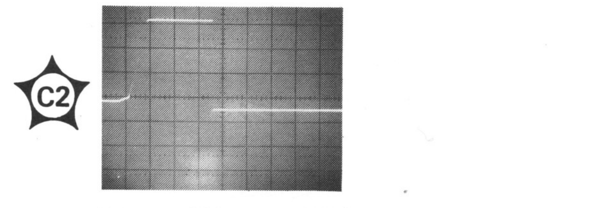
DC .5 V/DIV .1 SEC/DIV
(INITIATED BY POWER TURN-OFF)



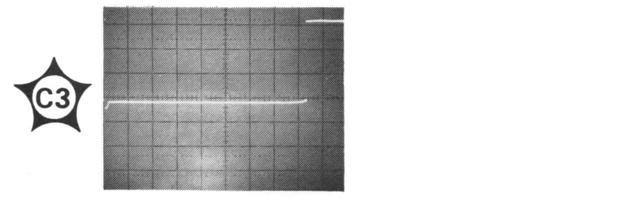
DC 1 V/DIV .1 SEC/DIV
(INITIATED BY POWER TURN-ON)



DC 1 V/DIV .1 SEC/DIV
(SCOPE TRIGGERED BY POWER TURN-OFF)



DC 1 V/DIV 1 mSEC/DIV
(INITIATED BY POWER TURN-OFF)



DC 1 V/DIV .1 SEC/DIV
(SCOPE TRIGGERED BY POWER-ON)

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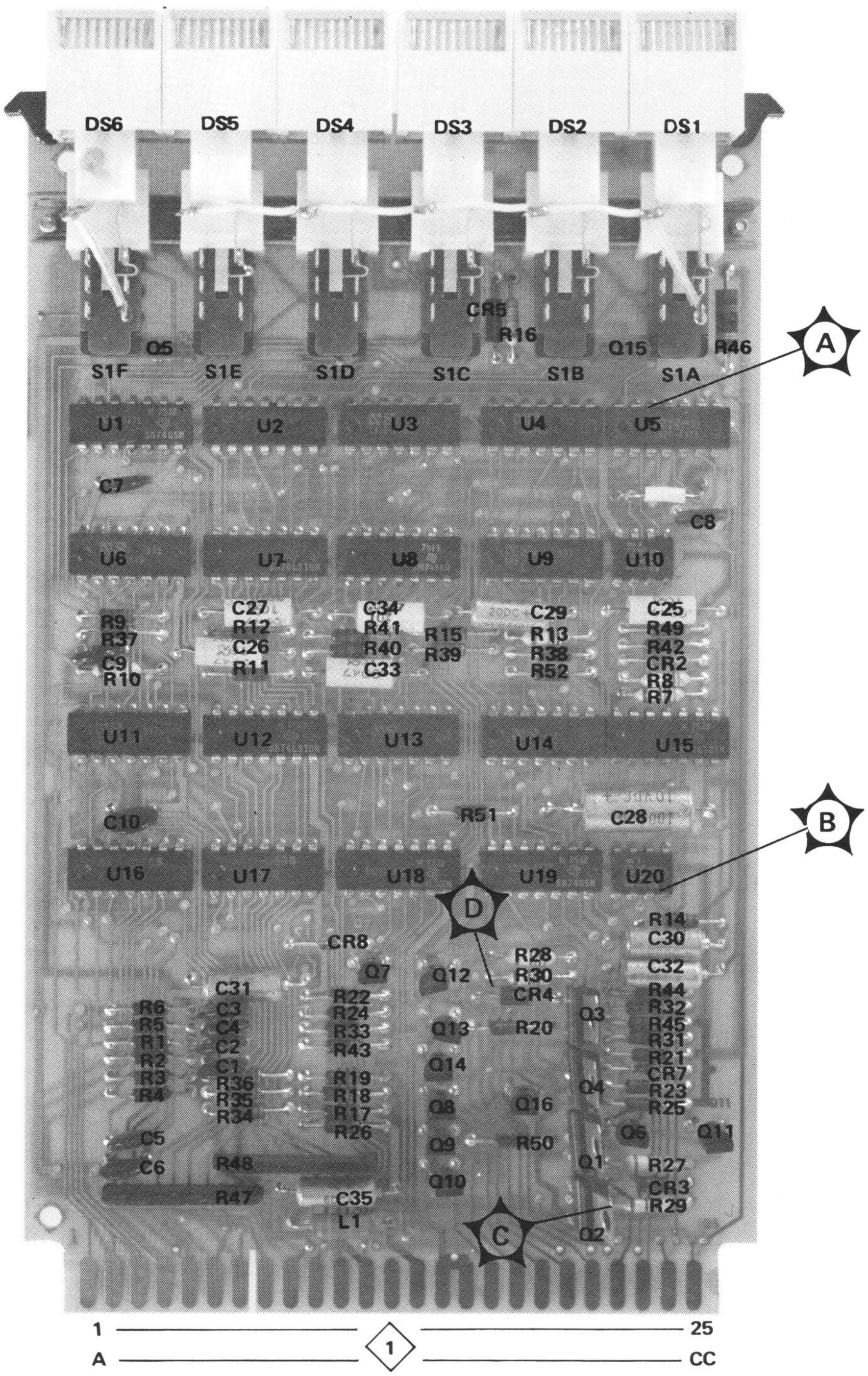
Figure 7-20. Meter Select/Power Detector PCA A5, Schematic Diagram (Model 3968A Illustrated)

Table 7-6. Mode Control PCA A6, Parts List

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A6	03968-60540	1	MODE CONTROL, PCA	28480	03968-60540
A6C1	0160-2055	11	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A6C2	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A6C3	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A6C4	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A6C5	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A6C6	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A6C7	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A6C8	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A6C9	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A6C10	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A6C11	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A6C25	0160-0157	5	CAPACITOR-FXD 4700PF +-10% 200WVDC POLYE	56289	292P47292
A6C26	0160-0157		CAPACITOR-FXD 4700PF +-10% 200WVDC POLYE	56289	292P47292
A6C27	0160-0157		CAPACITOR-FXD 4700PF +-10% 200WVDC POLYE	56289	292P47292
A6C28	0180-0137	1	CAPACITOR-FXD 100UF+-20% 10VDC TA	56289	150D107X0010R2
A6C29	0180-1746	1	CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A6C30	0180-0374	1	CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A6C31	0180-1704	2	CAPACITOR-FXD 47UF+-10% 6VDC TA	56289	150D476X9006B2
A6C32	0180-1704		CAPACITOR-FXD 47UF+-10% 6VDC TA	56289	150D476X9006B2
A6C33	0160-0157		CAPACITOR-FXD 4700PF +-10% 200WVDC POLYE	56289	292P47292
A6C34	0160-0157		CAPACITOR-FXD 4700PF +-10% 200WVDC POLYE	56289	292P47292
A6C35	0180-0106	1	CAPACITOR-FXD 60UF+-20% 6VDC TA	56289	150D606X0006B2
A6CR2	1901-0040	3	DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A6CR3	1901-0159	2	DIODE-PWR RECT 400V 750NA DO-41	04713	SR1358-4
A6CR4	1901-0159		DIODE-PWR RECT 400V 750NA DO-41	04713	SR1358-4
A6CR5	1902-0126	1	DIODE-ZNR 2.61V 5% DO-7 PD=.4W TC=-.073%	04713	SZ 10939-14
A6CR7	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A6CR8	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A6L1	9100-1619	1	COIL-FXD MOLDED RF CHOKE 6.8UH 10%	24226	15/681
A6Q1	1854-0565	4	TRANSISTOR NPN SI PD=1W FT=50MHZ	28480	1854-0565
A6Q2	1854-0565		TRANSISTOR NPN SI PD=1W FT=50MHZ	28480	1854-0565
A6Q3	1854-0565		TRANSISTOR NPN SI PD=1W FT=50MHZ	28480	1854-0565
A6Q4	1854-0565		TRANSISTOR NPN SI PD=1W FT=50MHZ	28480	1854-0565
A6Q5	1854-0300	1	TRANSISTOR NPN SI PD=25W FT=4MHZ	28480	1854-0300
A6Q6	1854-0071	8	TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A6Q7	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A6Q8	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A6Q9	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A6Q10	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A6Q11	1853-0036	2	TRANSISTOR PNP SIL PD=310MW FT=2507HZ	04713	SPS-3612
A6Q12	1853-0036		TRANSISTOR PNP SIL PD=310MW FT=2507HZ	04713	SPS-3612
A6Q13	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A6Q14	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A6Q15	1853-0073	1	TRANSISTOR PNP SI PD=25W FT=3MHZ	28480	1853-0073
A6Q16	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A6R1	0757-0283	6	RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
A6R2	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
A6R3	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
A6R4	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
A6R5	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
A6R6	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
A6R7	0757-0416	4	RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A6R8	0757-0416		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A6R9	0757-0419	15	RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R10	0698-3433	1	RESISTOR 28.7 1% .125W F TC=0+-100	03888	PME55-1/8-T0-28R7-F
A6R11	0698-3441	5	RESISTOR 215 1% .125W F TC=0+-100	16299	C4-1/8-T0-215R-F
A6R12	0698-3441		RESISTOR 215 1% .125W F TC=0+-100	16299	C4-1/8-T0-215R-F
A6R13	0757-0465	1	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A6R14	0698-3449	4	RESISTOR 28.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2872-F
A6R15	0757-0419		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R16	0698-4037	1	RESISTOR 46.4 1% .125W F TC=0+-100	16299	C4-1/8-T0-46R4-F
A6R17	0757-0419		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R18	0757-0419		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R19	0757-0419		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R20	0757-0419		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R21	0698-3449		RESISTOR 28.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2872-F
A6R22	0698-3449		RESISTOR 28.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2872-F
A6R23	0757-0419		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R24	0757-0419		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R25	0757-0438	2	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F

Table 7-6. Mode Control PCA A6, Parts List (Continued)

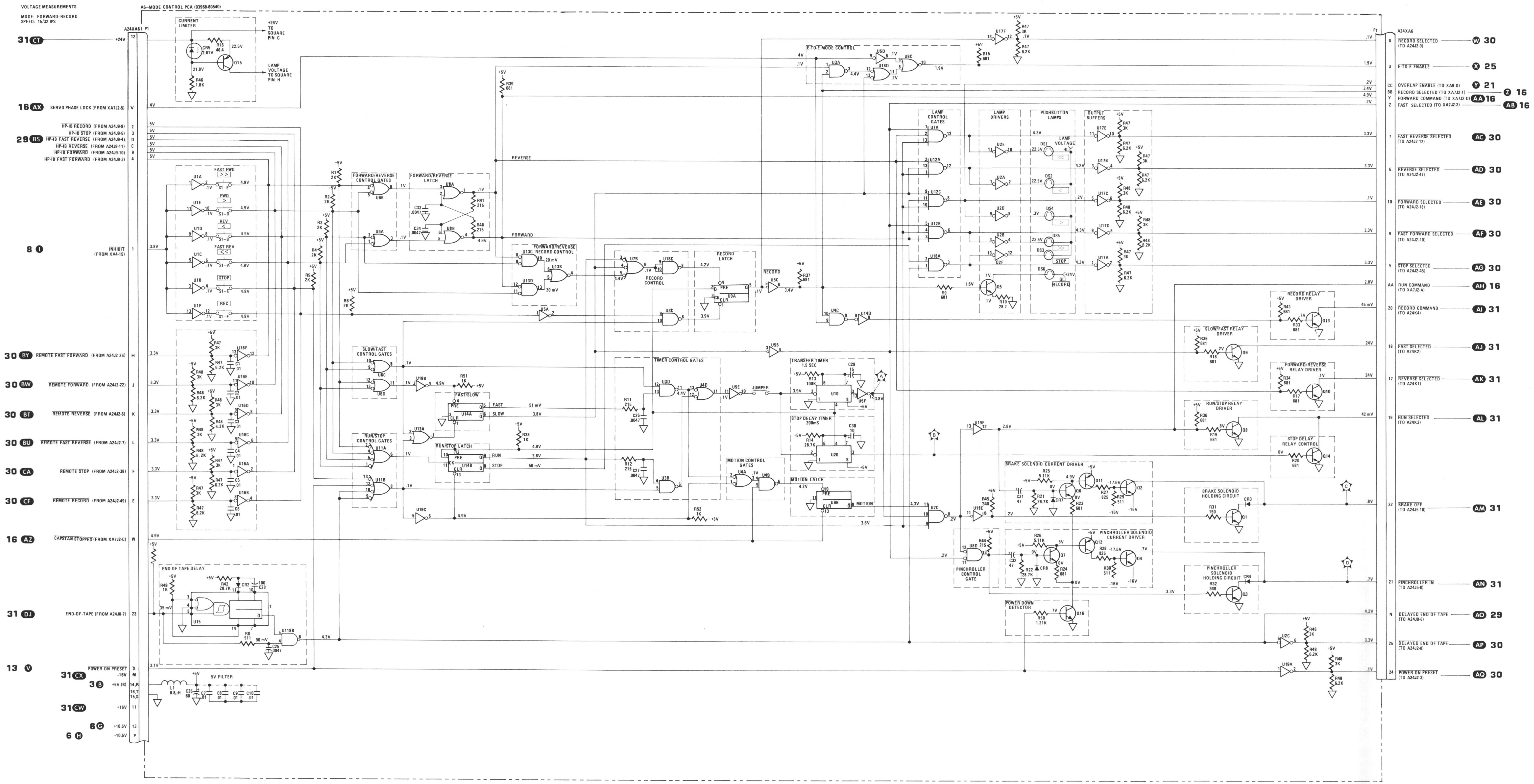
Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A6R26	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A6R27	0757-0421	2	RESISTOR 825 1% .125W F TC=0+-100	24546	C4-1/8-T0-825R-F
A6R28	0757-0421		RESISTOR 825 1% .125W F TC=0+-100	24546	C4-1/8-T0-825R-F
A6R29	0757-0416		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A6R30	0757-0416		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A6R31	0757-0284	1	RESISTOR 150 1% .125W F TC=0+-100	24546	C4-1/8-T0-151-F
A6R32	0698-3445	2	RESISTOR 348 1% .125W F TC=0+-100	16299	C4-1/8-T0-348R-F
A6R33	0757-0419		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R34	0757-0419		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R35	0757-0419		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R36	0757-0419		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R37	0757-0419		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R38	0757-0280	4	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A6R39	0757-0419		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R40	0698-3441		RESISTOR 215 1% .125W F TC=0+-100	16299	C4-1/8-T0-215R-F
A6R41	0698-3441		RESISTOR 215 1% .125W F TC=0+-100	16299	C4-1/8-T0-215R-F
A6R42	0698-3449		RESISTOR 28.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2872-F
A6R43	0757-0419		RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A6R44	0698-3441		RESISTOR 215 1% .125W F TC=0+-100	16299	C4-1/8-T0-215R-F
A6R45	0698-3445		RESISTOR 348 1% .125W F TC=0+-100	16299	C4-1/8-T0-348R-F
A6R46	0686-1825	1	RESISTOR 1.8K 5% .5W CC TC=0+647	01121	EB1825
A6R47	1810-0136	2	NETWORK-RES 10-PIN-SIP .1-PIN-SPCG	28480	1810-0136
A6R48	1810-0136		NETWORK-RES 10-PIN-SIP .1-PIN-SPCG	28480	1810-0136
A6R49	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A6R50	0757-0274	1	RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1213-F
A6R51	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A6R52	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A6S1	3101-1961	1	SWITCH-PB 6STA DPDT MOM .689 IN-CTRS .5A	28480	3101-1961
A6U1	1820-0175	2	IC SN74 05 N INV	01295	SN7405N
A6U2	1820-0668	3	IC SN74 07 N BUFFER	01295	SN7407N
A6U3	1820-0583	3	IC DM74L 00N GATE	27014	DM74L00N
A6U4	1820-0583		IC DM74L 00N GATE	27014	DM74L00N
A6U5	1820-0174	1	IC SN74 04 N INV	01295	SN7404N
A6U6	1820-0583		IC DM74L 00N GATE	27014	DM74L00N
A6U7	1820-1202	2	IC SN74LS 10 N GATE	01295	SN74LS10N
A6U8	1820-1124	1	IC SN74 33 N BUFFER	01295	SN7433N
A6U9	1820-0596	1	IC DM74L 74N FLIP-FLOP	27014	DM74L74N
A6U10	1826-0180	2	IC NE 555 TIMER	18324	NE555V
A6U11	1820-0588	1	IC DM74L 20N GATE	27014	DM74L20N
A6U12	1820-1202		IC SN74LS 10 N GATE	01295	SN74LS10N
A6U13	1820-0584	1	IC DM74L 02N GATE	27014	DM74L02N
A6U14	1820-0077	1	IC SN74 74 N FLIP-FLOP	01295	SN7474N
A6U15	1820-1270	1	IC SN74L 121 N MV	01295	SN74L121N
A6U16	1820-0668		IC SN74 07 N BUFFER	01295	SN7407N
A6U17	1820-0668		IC SN74 07 N BUFFER	01295	SN7407N
A6U18	1820-1197	1	IC SN74LS 00 N GATE	01295	SN74LS00N
A6U19	1820-0175		IC SN74 05 N INV	01295	SN7405N
A6U20	1826-0180		IC NE 555 TIMER	18324	NE555V
			A6 MISCELLANEOUS		
	0510-0843	2	PIN-SPRING SPIRAL PIN TYPE .062" DIA	00000	OBD
	4040-0750	2	EXTRACTOR-PC BD RED POLYC .062-BD-THKNS	28480	4040-0750
	8159-0005	1	WIRE 22AWG W PVC 1X22 80C	00736	L-2007-1
	03968-00007	2	LABEL, PUSHBUTTON	28480	03968-00007
	03968-00008	2	LABEL, PUSHBUTTON	28480	03968-00008
	03968-00009	1	LABEL, PUSHBUTTON	28480	03968-00009
	03968-00010	1	LABEL, PUSHBUTTON	28480	03968-00010
A6DS1	2140-0542	6	LAMP, INCANDESCENT, 24V	28480	2140-0542
A6DS2	2140-0542		LAMP, INCANDESCENT, 24V	28480	2140-0542
A6DS3	2140-0542		LAMP, INCANDESCENT, 24V	28480	2140-0542
A6DS4	2140-0542		LAMP, INCANDESCENT, 24V	28480	2140-0542
A6DS5	2140-0542		LAMP, INCANDESCENT, 24V	28480	2140-0542
A6DS6	2140-0542		LAMP, INCANDESCENT, 24V	28480	2140-0542



NOTE:

1. PINS 1 THROUGH 25 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH CC ARE ON THE REVERSE SIDE.

Figure 7-21. Mode Control PCA A6, Parts Location



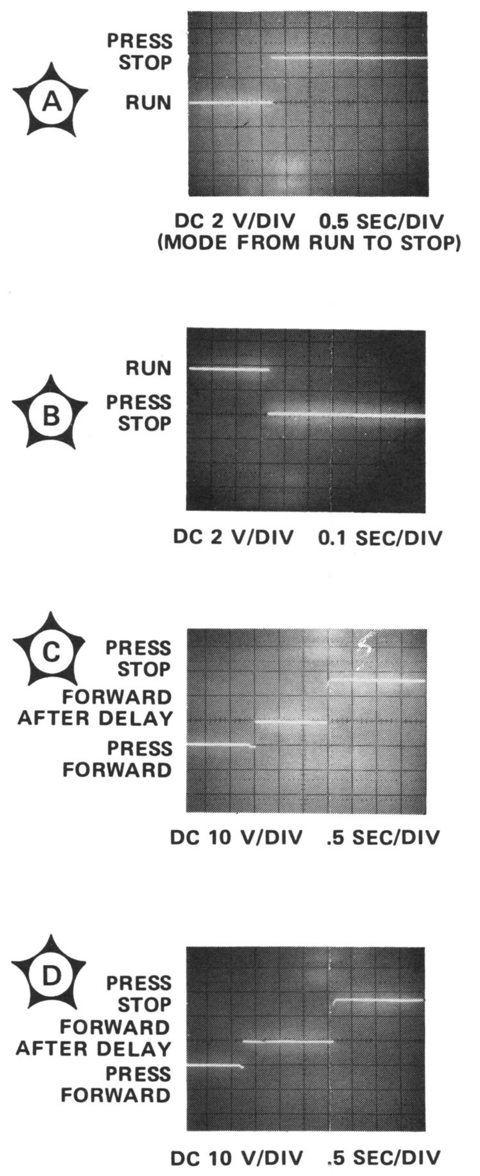


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Figure 7-22. Mode Control PCA A6, Schematic Diagram

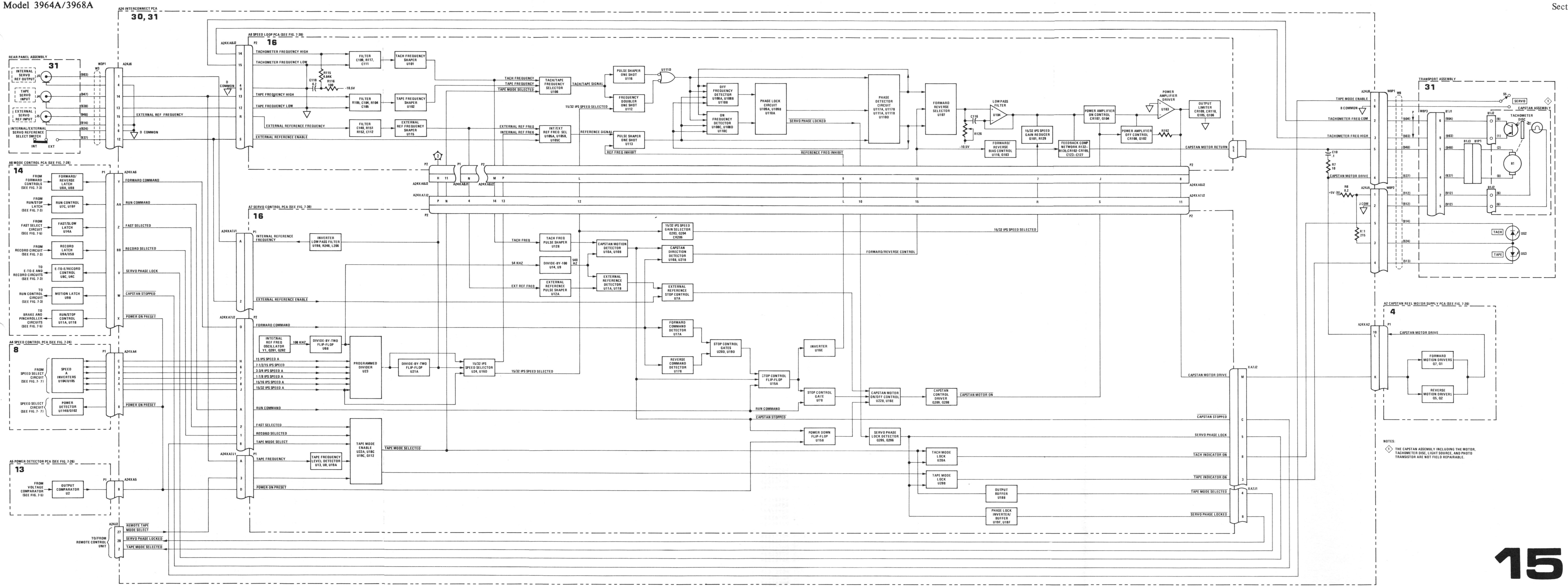

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Figure 7-23. Servo Loop and Servo Control Circuits, Servicing Diagram

Table 7-7. Servo Control Circuit, Parts List (Part of PCA A7)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A7	03968-60530	1	CALIBRATOR/SERVO CONTROL PCA (STANDARD)	28480	03968-60530
A7	03968-60531	1	CALIBRATOR/SERVO CONTROL PCA (OPTION 041)	28480	03968-60531
A7C201	0160-0168	1	CAPACITOR-FXD .1UF +-10% 200WVDC POLYE	56289	292P10492
A7C202	0150-0096	1	CAPACITOR-FXD .05UF +80-20% 100WVDC CER	28480	0150-0096
A7C203	0180-0161	1	CAPACITOR-FXD 3.3UF+-20% 35VDC TA	56289	150D335X0035B2
A7C204	0180-0374	1	CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A7C205	0160-0153		CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE	56289	292P10292
A7C206	0160-0153		CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE	56289	292P10292
A7C209	0160-0174	2	CAPACITOR-FXD .47UF +80-20% 25WVDC CER	28480	0160-0174
A7C210	0180-0228		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A7C211	0170-0040	1	CAPACITOR-FXD .047UF +-10% 200WVDC POLYE	56289	292P47392
A7C212	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A7C213	0180-1714		CAPACITOR-FXD 330UF+-10% 6VDC TA	56289	150D337X9006B2
A7C214	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A7C215	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A7C216	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A7C217	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A7C218	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A7C219	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A7C220	0160-0160	1	CAPACITOR-FXD 8200PF +-10% 200WVDC POLYE	56289	292P82292
A7C221	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A7C223	0160-2202	1	CAPACITOR-FXD 75PF +-5% 300WVDC MICA	28480	0160-2202
A7C224	0160-2204	1	CAPACITOR-FXD 100PF +-5% 300WVDC MICA	28480	0160-2204
A7C225	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A7CR1	1902-1259	8	DIODE-ZNR 1N5357B 20V 5% PD=5W IR=500NA	04713	1N5357B
A7CR2	1902-1259		DIODE-ZNR 1N5357B 20V 5% PD=5W IR=500NA	04713	1N5357B
A7CR4	1902-1259		DIODE-ZNR 1N5357B 20V 5% PD=5W IR=500NA	04713	1N5357B
A7CR5	1902-1259		DIODE-ZNR 1N5357B 20V 5% PD=5W IR=500NA	04713	1N5357B
A7CR201	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A7CR202	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A7CR203	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A7CR204	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A7CR206	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A7J1	1250-0118	1	CONNECTOR-RF BNC FEM SGL-HOLE-FR 50-OHM	24931	28JR128-1
A7L201	9100-1618		COIL-MLD 5.6UH 10% Q=45 .155DX.375LG	99800	1537-30
A7L204	9100-1620	2	COIL-MLD 15UH 10% Q=65 .155DX.375LG	24226	15/152
A7L206	9100-1644	1	COIL-MLD 330UH 5% Q=65 .19DX.44LG	24226	19/333
A7Q201	1853-0036	3	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
A7Q202	1854-0071	6	TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A7Q203	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A7Q204	1853-0036		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
A7Q205	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A7Q206	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A7Q208	1853-0036		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
A7Q209	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A7Q212	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A7R29	0757-0198		RESISTOR 100 1% .5W F TC=0+-100	19701	MF7C1/2-T0-101-F
A7R30	0757-0198		RESISTOR 100 1% .5W F TC=0+-100	19701	MF7C1/2-T0-101-F
A7R44	0757-0198		RESISTOR 100 1% .5W F TC=0+-100	19701	MF7C1/2-T0-101-F
A7R45	0757-0198		RESISTOR 100 1% .5W F TC=0+-100	19701	MF7C1/2-T0-101-F
A7R170	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R171	0757-0449		RESISTOR 20K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2002-F
A7R172	0757-0290	3	RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A7R173	0757-0279	4	RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A7R201	0757-0274	1	RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1213-F
A7R202	0698-3266	1	RESISTOR 237K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2373-F
A7R203	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F
A7R204	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R205	0757-0279		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A7R206	0757-0280	8	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A7R207	0757-0401	1	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A7R208	0757-0419	1	RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A7R209	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R210	0757-0458	1	RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A7R211	0757-0441	1	RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F
A7R212	0698-3454	1	RESISTOR 215K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2153-F
A7R213	0698-3453	1	RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F
A7R216	0757-0446	4	RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A7R217	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A7R218	0757-0461	3	RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F
A7R219	0757-0283	1	RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F

Table 7-7. Servo Control Circuit, Parts List (Part of PCA A7) (Continued)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A7R220	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R221	0757-0317	1	RESISTOR 1.33K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1331-F
A7R222	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A7R223	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R224	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A7R225	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R226	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R227	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A7R229	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A7R230	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A7R231	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R232	0757-0461		RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F
A7R240	0757-0279		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A7R246	0698-3440	1	RESISTOR 196 1% .125W F TC=0+-100	24546	C4-1/8-T0-196R-F
A7R247	0757-0279		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A7R248	0698-0085	1	RESISTOR 2.61K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2611-F
A7R249	0757-0290		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A7R250	0757-0290		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A7R251	0698-3432	1	RESISTOR 26.1 1% .125W F TC=0+-100	03888	PME55-1/8-T0-26R1-F
A7R252	0757-0461		RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F
A7R255	0698-0083		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A7R256	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R257	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R258	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A7R290	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A7R291	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A7R292	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A7U6	1820-1112	5	IC-DIGITAL SN74LS74N TTL LS DUAL	01295	SN74LS74N
A7U7	1820-1074	1	IC-DIGITAL SN74128N TTL QUAD 2 NOR	01295	SN74128N
A7U8	1826-0065	1	IC LM 311 COMPARATOR	27014	LM311N
A7U9	1820-0055	2	IC-DIGITAL SN7490N TTL DECD SYNCHRO	01295	SN7490N
A7U10	1820-1112		IC-DIGITAL SN74LS74N TTL LS DUAL	01295	SN74LS74N
A7U11	1820-1112		IC-DIGITAL SN74LS74N TTL LS DUAL	01295	SN74LS74N
A7U12	1820-1247	2	IC-DIGITAL SN74L123N TTL L DUAL	01295	SN74L123N
A7U13	1820-0477	1	IC LM 301A OP AMP	27014	LM301AN
A7U14	1820-0055		IC-DIGITAL SN7490N TTL DECD SYNCHRO	01295	SN7490N
A7U15	1820-1112		IC-DIGITAL SN74LS74N TTL LS DUAL	01295	SN74LS74N
A7U16	1820-1199	2	IC-DIGITAL SN74LS04N TTL LS HEX 1	01295	SN74LS04N
A7U17	1820-1247		IC-DIGITAL SN74L123N TTL L DUAL	01295	SN74L123N
A7U18	1820-0668	1	IC-DIGITAL SN7407N TTL HEX 1 NON-INV	01295	SN7407N
A7U19	1820-1199		IC-DIGITAL SN74LS04N TTL LS HEX 1	01295	SN74LS04N
A7U20	1820-1197	2	IC-DIGITAL SN74LS00N TTL LS QUAD 2 NAND	01295	SN74LS00N
A7U21	1820-1112		IC-DIGITAL SN74LS74N TTL LS DUAL	01295	SN74LS74N
A7U22	1820-0655	1	IC-DIGITAL SN7425N TTL DUAL 4 NOR	01295	SN7425N
A7U23	1820-0744	1	IC-DIGITAL SN7497N TTL BIN SYNCHRO	01295	SN7497N
A7U24	1820-1197		IC-DIGITAL SN74LS00N TTL LS QUAD 2 NAND	01295	SN74LS00N
A7XX201	1200-0199	1	SOCKET-XTAL 2-CONT HC-6/U-PKG	91506	8000-AG9
A7Y1	0410-0191	1	CRYSTAL:108.000KHZ (FOR STANDARD INSTRUMENT ONLY)	28480	0410-0191
A7Y1	0410-0010	1	CRYSTAL:100KC (FOR OPTION 041 INSTRUMENT ONLY)	28480	0410-0010
			A7 MISCELLANEOUS		
	0360-1190	1	TERMINAL-LUG-SLDR 3/8 SCR .38/.078 ID	79963	720-.380H
	0360-1514	2	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
	0362-0227	2	TERMINAL-CRIMP QDISC-FEM 30-24-AWG	28480	0362-0227
	0380-0917	6	SPACER-RND .125LG .115ID .2500 FBR	06540	9222
	2190-0163	1	WASHER-LK INTL T NO.-3/8 .38-IN-ID	78189	1220-05
	2260-0009	6	NUT-HEX-W/LKWR 4-40-THD .094-THK .25-A/F	28480	2260-0011
	2950-0001	1	NUT-HEX-DBL-CHAM 3/8-32-THD .094-THK	28480	2950-0030
	3131-0383	10	BUTTON-PB-SW HARVEST GOLD; .398-IN W	71590	J52312 HARVEST GOLD
	8150-0301		WIRE 24AWG R 1000V PVC 7X32 105C	28480	8150-0301
	8150-0302		WIRE 24AWG BR 1000V PVC 7X32 105C	28480	8150-0302
	5040-0702	2	INSULATOR:CONNECTOR	28480	5040-0702
	03968-00231	1	SERVO SHIELD, MARKER	28480	03968-00231
	03968-20070	2	GUIDE, BOARD	28480	03968-20070

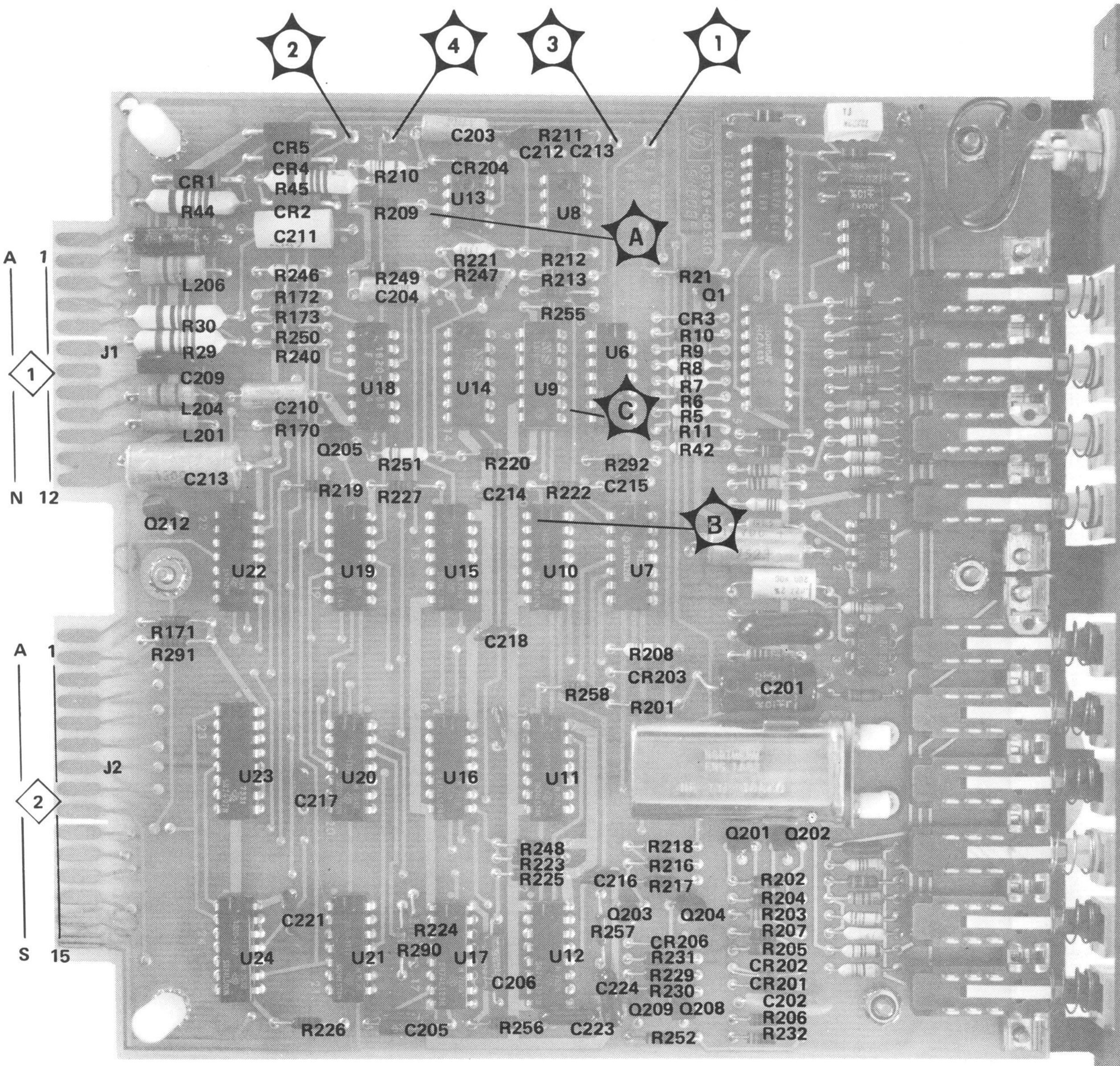
Table 7-8. Servo Loop Circuit, Parts List (Part of PCA A8)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A8	03968-60520	1	VOICE/SERVO PCA	28480	03968-60520
A8C101	0180-1714	1	CAPACITOR-FXD 330UF+-10% 6VDC TA	56289	150D337X900682
A8C102	0180-0228		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X901582
A8C103	0180-0228		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X901582
A8C104	0170-0040	2	CAPACITOR-FXD .047UF +-10% 200WVDC POLYE	56289	292P47392
A8C105	0140-0222	3	CAPACITOR-FXD 240PF +-1% 300WVDC MICA	72136	DM15F241F0300WV1C
A8C109	0160-0161	1	CAPACITOR-FXD .01UF +-10% 200WVDC POLYE	56289	292P10392
A8C110	0180-0100		CAPACITOR-FXD 4.7UF+-10% 35VDC TA	56289	150D475X9035B2
A8C111	0140-0222		CAPACITOR-FXD 240PF +-1% 300WVDC MICA	72136	DM15F241F0300WV1C
A8C112	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C113	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C114	0160-2202	3	CAPACITOR-FXD 75PF +-5% 300WVDC MICA	28480	0160-2202
A8C115	0180-0218	1	CAPACITOR-FXD .15UF+-10% 35VDC TA	56289	150D154X9035A2
A8C116	0160-0303	2	CAPACITOR-FXD .15UF +-10% 200WVDC POLYE	56289	292P15492
A8C117	0160-0194		CAPACITOR-FXD .015UF +-10% 200WVDC POLYE	56289	292P15392
A8C118	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C119	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C120	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C121	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C123	0160-0153	1	CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE	56289	292P10292
A8C124	0180-0374	3	CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A8C125	0160-0303		CAPACITOR-FXD .15UF +-10% 200WVDC POLYE	56289	292P15492
A8C127	0180-0374		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A8C128	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C129	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C130	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C131	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C132	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C133	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C134	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C135	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C136	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C140	0170-0040		CAPACITOR-FXD .047UF +-10% 200WVDC POLYE	56289	292P47392
A8C142	0140-0222		CAPACITOR-FXD 240PF +-1% 300WVDC MICA	72136	DM15F241F0300WV1C
A8C143	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C144	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C146	0180-0374		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A8C147	0160-2202		CAPACITOR-FXD 75PF +-5% 300WVDC MICA	28480	0160-2202
A8C148	0160-2202		CAPACITOR-FXD 75PF +-5% 300WVDC MICA	28480	0160-2202
A8CR101	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR102	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR103	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR104	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR105	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR107	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR108	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR109	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR110	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8J1	1251-1123	1	CONNECTOR-SGL CONT SKT .08-IN-BSC-SZ RND	74970	105-0752-001
	1251-0070	2	CONNECTOR-TEL JACK 3-CKTS .25-SHK-DIA	82389	2J-1581
A8L101	9100-1618	1	COIL-MLD 5.6UH 10% Q=45 .155DX.375LG	99800	1537-30
A8L102	9100-1620		COIL-MLD 15UH 10% Q=65 .155DX.375LG	24226	15/152
A8L103	9100-1620		COIL-MLD 15UH 10% Q=65 .155DX.375LG	24226	15/152
A8Q101	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
A8Q102	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
A8Q103	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
A8Q104	1855-0052	1	TRANSISTOR MOSFET P-CHAN D-MODE TO-92 SI	07263	2N4360
A8Q105	1854-0215	1	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A8Q106	1853-0036	1	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
A8R103	0698-3155	8	RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F
A8R104	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F
A8R105	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
A8R106	0757-0438	3	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A8R107	0757-0400	3	RESISTOR 90.9 1% .125W F TC=0+-100	24546	C4-1/8-T0-90R9-F
A8R108	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F
A8R109	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A8R114	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F
A8R115	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F
A8R116	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A8R117	0757-0199	3	RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A8R118	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
A8R119	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A8R120	0757-0400		RESISTOR 90.9 1% .125W F TC=0+-100	24546	C4-1/8-T0-90R9-F
A8R122	0757-0441		RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F

Table 7-8. Servo Loop Circuit, Parts List (Part of PCA A8) (Continued)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A8R123	0757-0424	1	RESISTOR 1.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1101-F
A8R124	0757-0288		RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F
A8R125	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A8R126	2100-3353	1	RESISTOR-TRMR 20K 10% C SIDE-ADJ 1-TRN	32997	3386X-Y46-203
A8R127	0698-3153	1	RESISTOR 3.83K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3831-F
A8R128	0698-3160	1	RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A8R129	0698-3152	1	RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F
A8R130	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A8R132	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A8R133	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A8R134	0698-3442	1	RESISTOR 237 1% .125W F TC=0+-100	24546	C4-1/8-T0-237R-F
A8R135	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F
A8R136	0811-3406	1	RESISTOR .5 5% 7W PW TC=0+-90	91637	RS-7
A8R137	0757-0458		RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A8R145	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
A8R151	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F
A8R152	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F
A8R153	0757-0400		RESISTOR 90.9 1% .125W F TC=0+-100	24546	C4-1/8-T0-90R9-F
A8R154	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A8R155	0757-0123	1	RESISTOR 34.8K 1% .125W F TC=0+-100	24546	C4, T=0
A8R156	0698-3156	1	RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A8R157	0757-0483	1	RESISTOR 562K 1% .125W F TC=0+-100	19701	MF5C1/8-T0-5623-F
A8R158	0686-2255	1	RESISTOR 2.2M 5% .5W CC TC=0+1000	01121	EB2255
A8R160	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A8R161	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A8R162	0757-0458		RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A8R163	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A8R164	0698-3432	1	RESISTOR 26.1 1% .125W F TC=0+-100	03888	PME55-1/8-T0-26R1-F
A8R165	0757-0316	1	RESISTOR 42.2 1% .125W F TC=0+-100	24546	C4-1/8-T0-42R2-F
A8U101	1826-0065	3	IC LM 311 COMPARATOR	27014	LM311N
A8U102	1826-0065		IC LM 311 COMPARATOR	27014	LM311N
A8U103	1820-0493		IC LM 307 OP AMP	27014	LM307N
A8U104	1820-0493		IC LM 307 OP AMP	27014	LM307N
A8U105	1820-0054	2	IC-DIGITAL SN7400N TTL QUAD 2 NAND	01295	SN7400N
A8U106	1820-1197	5	IC-DIGITAL SN74LS00N TTL LS QUAD 2 NAND	01295	SN74LS00N
A8U107	1820-1197		IC-DIGITAL SN74LS00N TTL LS QUAD 2 NAND	01295	SN74LS00N
A8U108	1820-1197		IC-DIGITAL SN74LS00N TTL LS QUAD 2 NAND	01295	SN74LS00N
A8U109	1820-1112	2	IC-DIGITAL SN74LS74N TTL LS DUAL	01295	SN74LS74N
A8U110	1820-1201	1	IC-DIGITAL SN74LS08N TTL LS QUAD 2 AND	01295	SN74LS08N
A8U111	1820-1197		IC-DIGITAL SN74LS00N TTL LS QUAD 2 NAND	01295	SN74LS00N
A8U112	1820-0261	3	IC-DIGITAL SN74121N TTL MONOSTBL	01295	SN74121N
A8U113	1820-0261		IC-DIGITAL SN74121N TTL MONOSTBL	01295	SN74121N
A8U115	1826-0065		IC LM 311 COMPARATOR	27014	LM311N
A8U116	1820-0493		IC LM 307 OP AMP	27014	LM307N
A8U120	1820-1112		IC-DIGITAL SN74LS74N TTL LS DUAL	01295	SN74LS74N
A8U152	1820-0261		IC-DIGITAL SN74121N TTL MONOSTBL	01295	SN74121N
			A8 MISCELLANEOUS (REFER TO TABLE 7-)		

SERVO CONTROL – PCA A7



NOTES:

1. J1 PINS 1 THROUGH 12 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH N ARE ON THE REVERSE SIDE.

2. J2 PINS 1 THROUGH 15 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH S ARE ON THE REVERSE SIDE.

Figure 7-24. Servo Loop and Servo Control, Parts Location (Sheet 1 of 2)

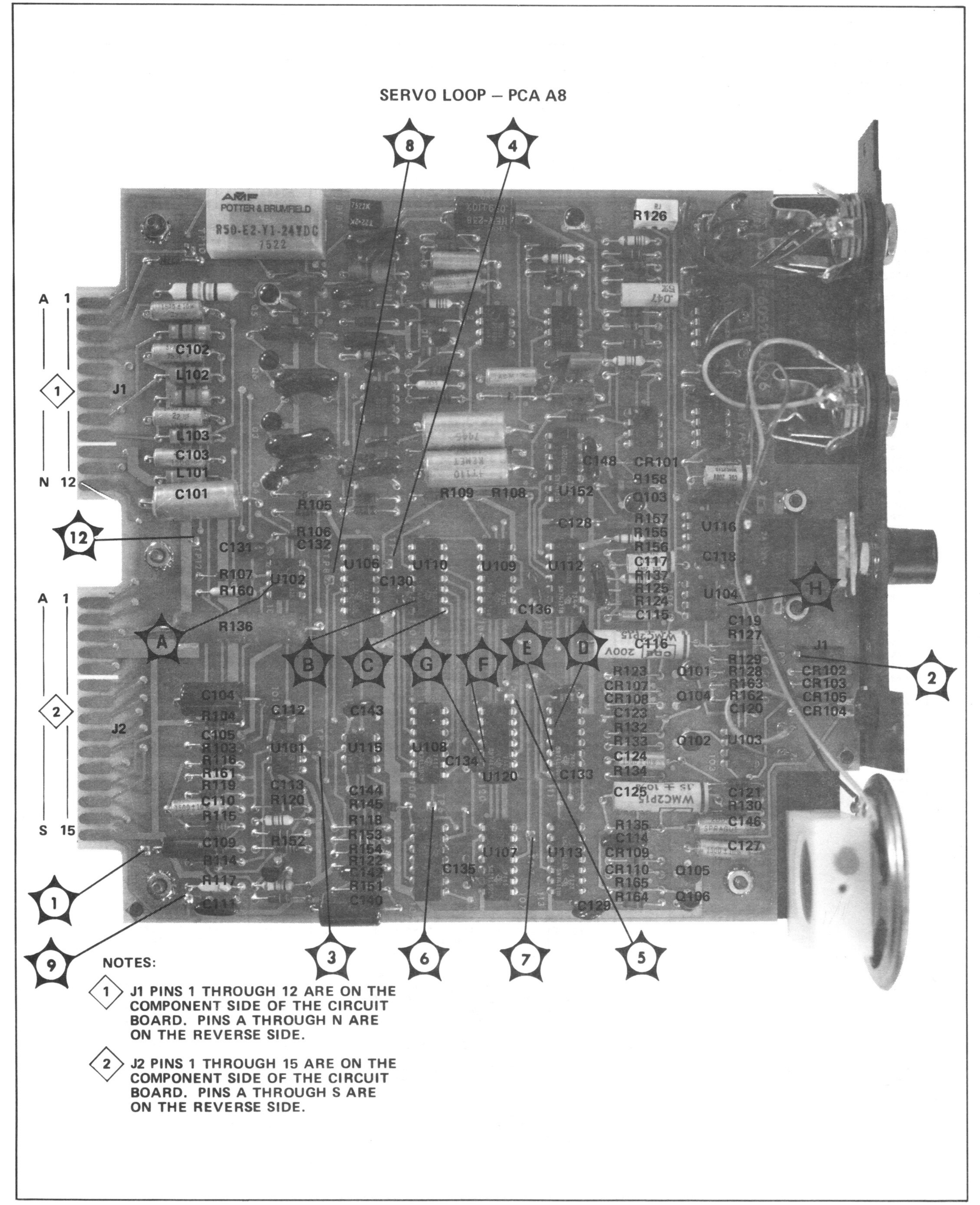
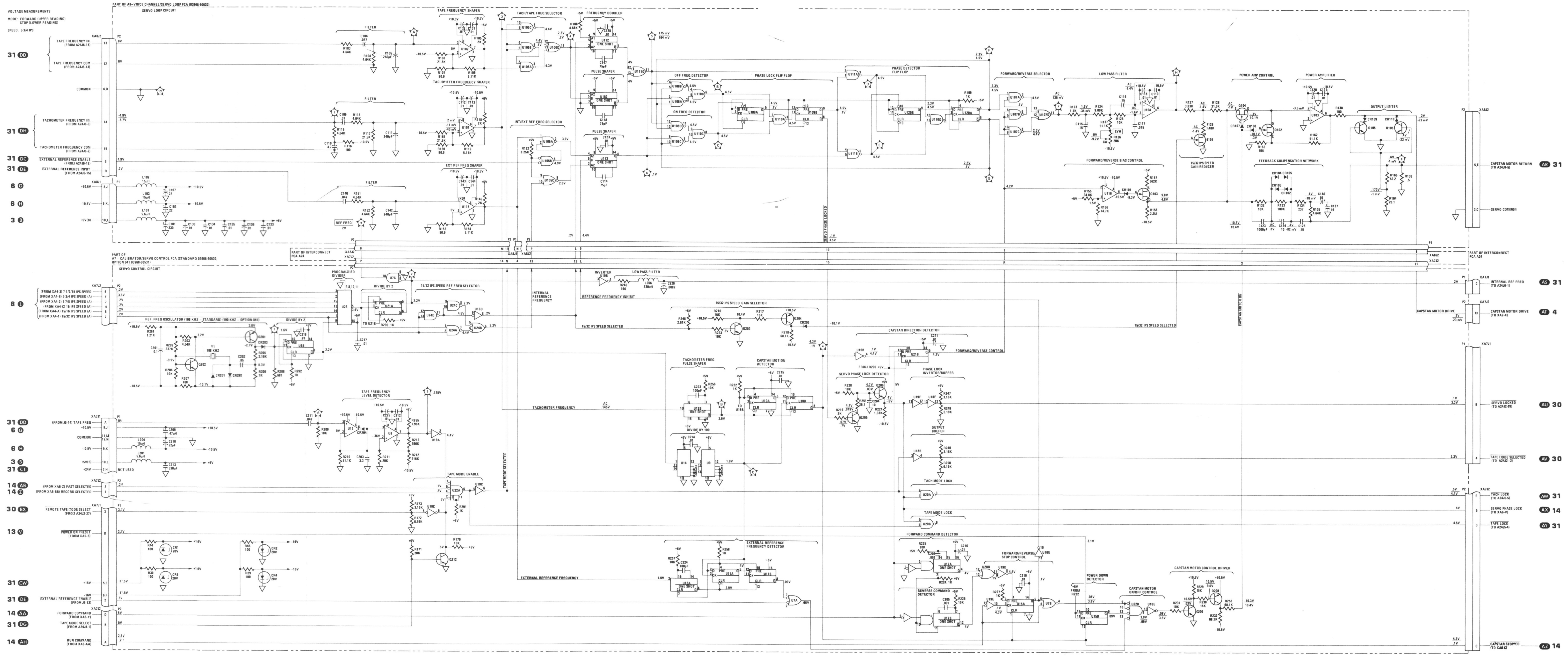
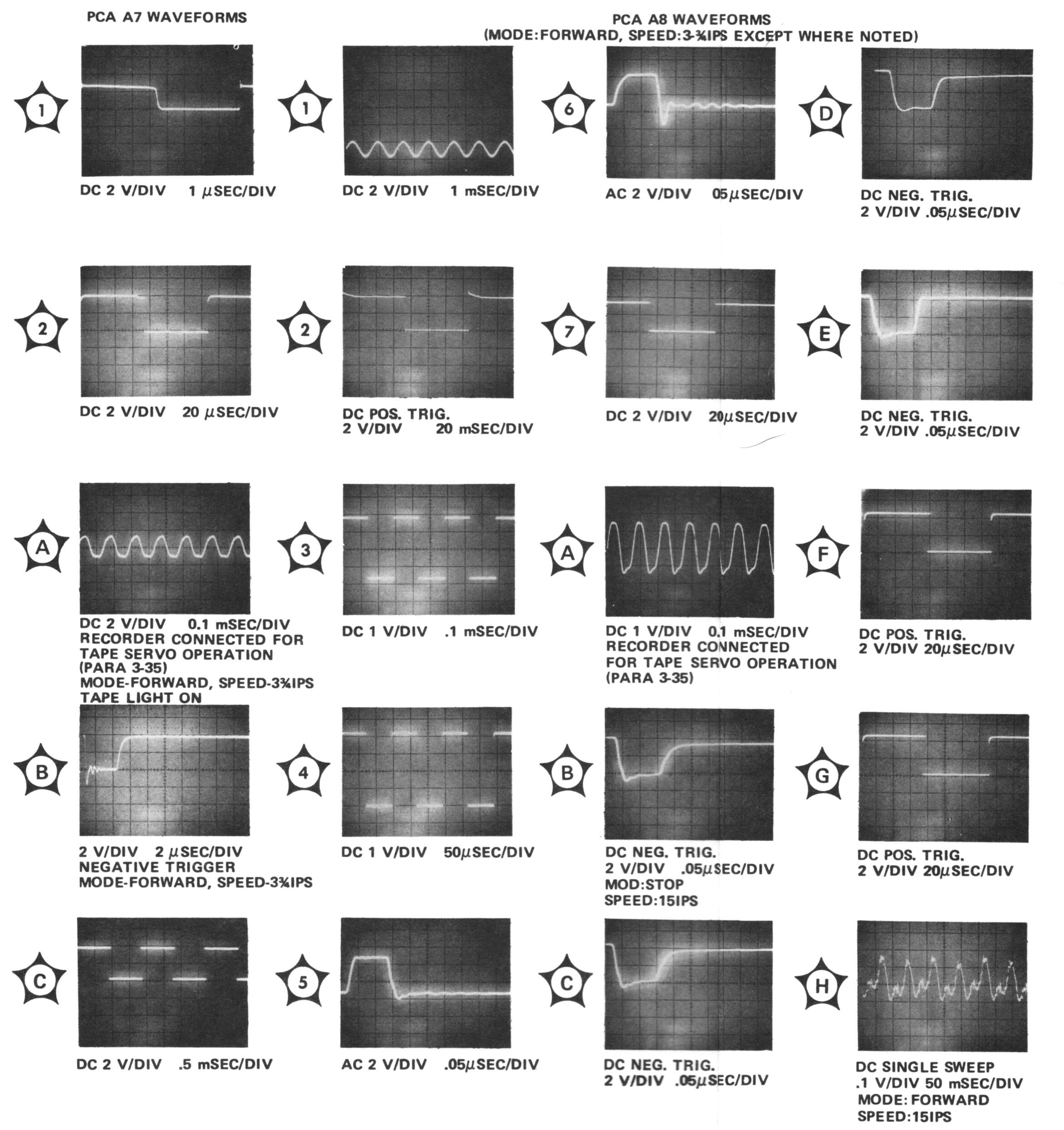


Figure 7-24. Servo Loop and Servo Control, Parts Location (Sheet 2 of 2)





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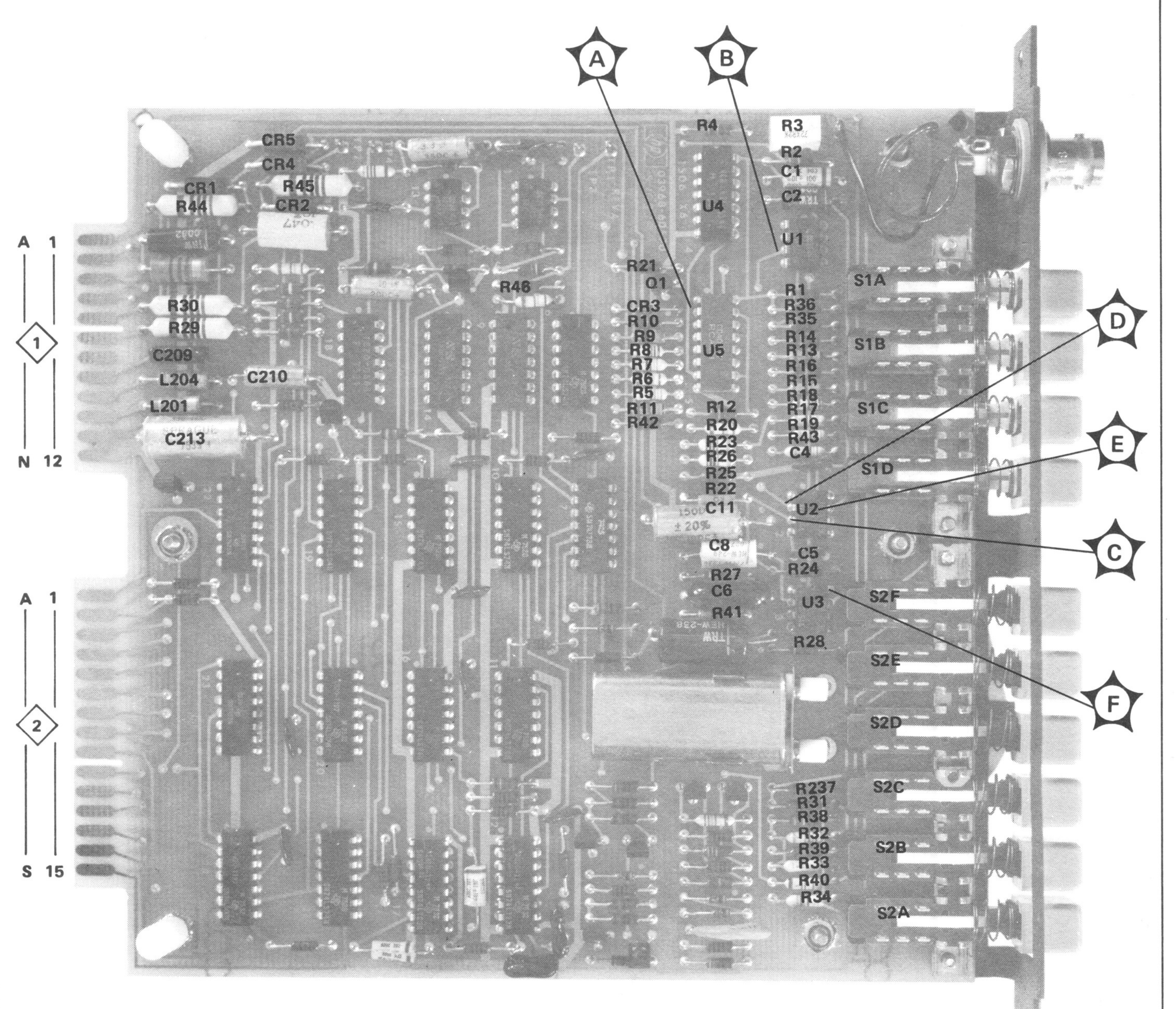
SERVICE SHEET

Figure 7-25. Servo Loop and Servo Control Circuits, Schematic Diagram (Part of PCA A7, A8)

Table 7-9. Calibrator Circuit, Parts List (Part of PCA A7)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A7	03968-60530	1	CALIBRATOR/SERVO CONTROL PCA	28480	03968-60530
A7	03968-60531	1	CALIBRATOR/SERVO CONTROL PCA	28480	03968-60531
A7C1	0160-0153	3	CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE	56289	292P10292
A7C2	0160-0157	1	CAPACITOR-FXD 4700PF +-10% 200WVDC POLYE	56289	292P47292
A7C4	0160-2055	11	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A7C5	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A7C6	0160-4348	1	CAPACITOR-FXD 6800PF +-1% 100WVDC MICA	56289	424ME6801F10103B
A7C8	0160-3426	1	CAPACITOR-FXD .027UF +-2% 200WVDC MET	28480	0160-3426
A7C11	0180-0137	1	CAPACITOR-FXD 100UF+-20% 10VDC TA	56289	150D107X0010R2
A7C209	0160-0174		CAPACITOR-FXD .47UF +80-20% 25WVDC CER	28480	0160-0174
A7C210	0180-0228	2	CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A7C213	0180-1714	2	CAPACITOR-FXD 330UF+-10% 6VDC TA	56289	150D337X9006B2
A7CR1	1902-1259		DIODE-ZNR 1N5357B 20V 5% PD=5W IR=500NA	04713	1N5357B
A7CR2	1902-1259		DIODE-ZNR 1N5357B 20V 5% PD=5W IR=500NA	04713	1N5357B
A7CR3	1901-0040	6	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A7CR4	1902-1259		DIODE-ZNR 1N5357B 20V 5% PD=5W IR=500NA	04713	1N5357B
A7CR5	1902-1259		DIODE-ZNR 1N5357B 20V 5% PD=5W IR=500NA	04713	1N5357B
A7L201	9100-1618	2	COIL-MLD 5.6UH 10% Q=45 .155DX.375LG	99800	1537-30
A7L204	9100-1620		COIL-MLD 15UH 10% Q=65 .155DX.375LG	24226	15/152
A7Q1	1854-0215	1	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A7R1	0698-3155	2	RESISTOR 4.64K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4641-F
A7R2	0757-0418	2	RESISTOR 619 1% .125W F TC=0+-100	24546	C4-1/8-T0-619R-F
A7R3	2100-3273	1	RESISTOR-TRMR 2K 10% C SIDE-ADJ 1-TRN	73138	72-144-0
A7R4	0757-0288	1	RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F
A7R5	0698-8641	2	RESISTOR 47.5K .1% .125W F TC=0+-25	24546	NE55
A7R6	0698-0083	3	RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A7R7	0698-8642	2	RESISTOR 56.2K .1% .125W F TC=0+-25	24546	NE55
A7R8	0757-0430	2	RESISTOR 2.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2211-F
A7R9	0698-8643	2	RESISTOR 84.5K .1% .125W F TC=0+-25	24546	NE55
A7R10	0698-3150	2	RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F
A7R11	0698-6621	2	RESISTOR 250K .1% .125W F TC=0+-25	24546	NE55
A7R12	0698-4424	2	RESISTOR 1.4K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1401-F
A7R13	0698-6621		RESISTOR 250K .1% .125W F TC=0+-25	24546	NE55
A7R14	0698-4424		RESISTOR 1.4K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1401-F
A7R15	0698-8643		RESISTOR 84.5K .1% .125W F TC=0+-25	24546	NE55
A7R16	0698-3150		RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F
A7R17	0698-8642		RESISTOR 56.2K .1% .125W F TC=0+-25	24546	NE55
A7R18	0757-0430		RESISTOR 2.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2211-F
A7R19	0698-8641		RESISTOR 47.5K .1% .125W F TC=0+-25	24546	NE55
A7R20	0698-0083		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A7R21	0757-0449	2	RESISTOR 20K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2002-F
A7R22	0698-7382	1	RESISTOR 103.5K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-10352-B
A7R23	0698-6358	2	RESISTOR 100K .1% .125W F TC=0+-25	24546	NE55
A7R24	0698-6320	3	RESISTOR 5K .1% .125W F TC=0+-25	03888	PME55-1/8-T9-5001-B
A7R25	0698-6320		RESISTOR 5K .1% .125W F TC=0+-25	03888	PME55-1/8-T9-5001-B
A7R26	0698-6358		RESISTOR 100K .1% .125W F TC=0+-25	24546	NE55
A7R27	0698-3157	1	RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A7R28	0757-1099	1	RESISTOR 900 1% .125W F TC=0+-100	24546	C4-1/8-T0-901-F
A7R29	0757-0198	8	RESISTOR 100 1% .5W F TC=0+-100	19701	MF7C1/2-T0-101-F
A7R30	0757-0198		RESISTOR 100 1% .5W F TC=0+-100	19701	MF7C1/2-T0-101-F
A7R31	0698-6320		RESISTOR 5K .1% .125W F TC=0+-25	03888	PME55-1/8-T9-5001-B
A7R32	0698-6631	1	RESISTOR 2.5K .1% .125W F TC=0+-25	24546	NE55
A7R33	0698-8631	1	RESISTOR 1.085K .1% .125W F TC=0+-25	24546	NE55
A7R34	0698-8632	1	RESISTOR 414 .1% .125W F TC=0+-25	24546	NE55
A7R35	0698-5852	2	RESISTOR 500 1% .125W F TC=0+-100	24546	C4-1/8-T0-500R-F
A7R36	0698-5852		RESISTOR 500 1% .125W F TC=0+-100	24546	C4-1/8-T0-500R-F
A7R37	0698-3275	1	RESISTOR 2.5K 1% .125W F TC=0+-25	24546	NE55
A7R38	0757-0418		RESISTOR 619 1% .125W F TC=0+-100	24546	C4-1/8-T0-619R-F
A7R39	0698-4422	1	RESISTOR 1.27K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1271-F
A7R40	0698-6759	1	RESISTOR 1.6K 1% .125W F TC=0+-25	24546	NE55
A7R41	0698-6362	1	RESISTOR 1K .1% .125W F TC=0+-25	24546	NE55
A7R42	0757-0428	1	RESISTOR 1.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1621-F
A7R43	0698-6619	1	RESISTOR 15K .1% .125W F TC=0+-25	24546	NE55
A7R44	0757-0198		RESISTOR 100 1% .5W F TC=0+-100	19701	MF7C1/2-T0-101-F
A7R45	0757-0198		RESISTOR 100 1% .5W F TC=0+-100	19701	MF7C1/2-T0-101-F
A7R46	0757-0442	11	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7S1	3101-1659	1	SWITCH-PB 4-STATION 12.5MM C-C SPACING	28480	3101-1659
A7S2	3101-1962	1	SWITCH-PB 6-STATION 12.5MM C-C SPACING	28480	3101-1962
A7U1	1826-0269	1	IC FCN GEN	28480	1826-0269
A7U2	1826-0296	2	IC CA 207 OP AMP	02735	CA207E
A7U3	1826-0296		IC CA 207 OP AMP	02735	CA207E
A7U4	1820-0946	1	IC-DIGITAL CD4001AE CMOS QUAD 2 NOR	02735	CD4001AY
A7U5	1820-0976	1	IC-DIGITAL CD4015AE CMOS DUAL D-TYPE	02735	CD4015AY

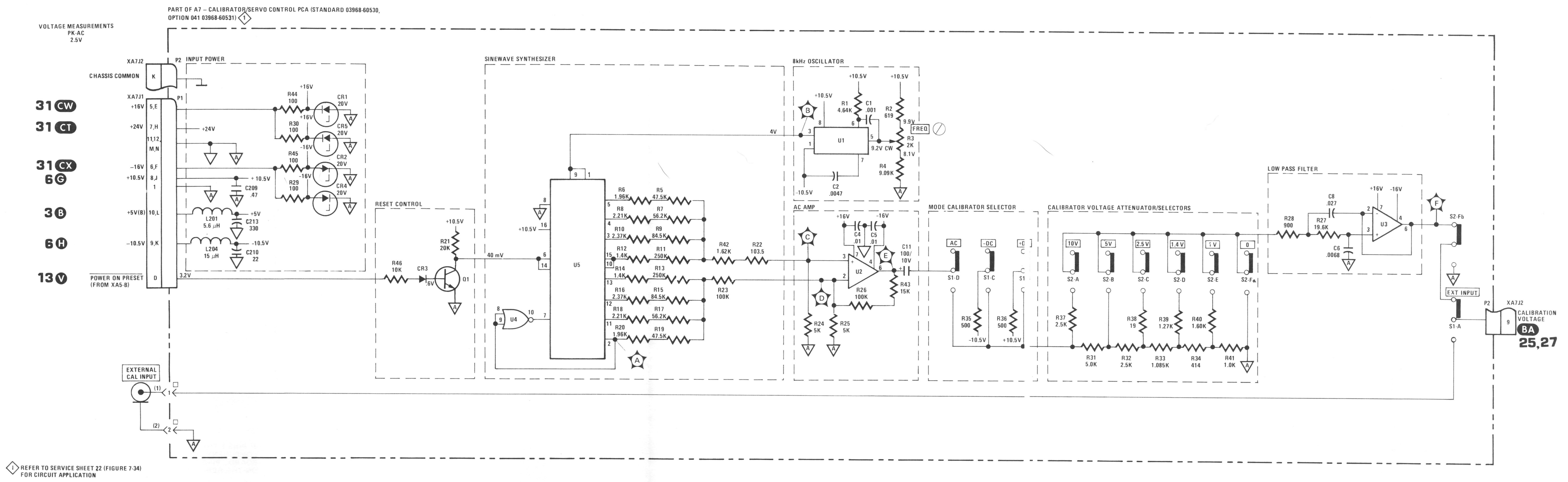


NOTES:

1. J1 PINS 1 THROUGH 12 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH N ARE ON THE REVERSE SIDE.

2. J2 PINS 1 THROUGH 15 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH S ARE ON THE REVERSE SIDE.

Figure 7-26. Calibrator Circuit, Parts Location (Part of PCA A7)



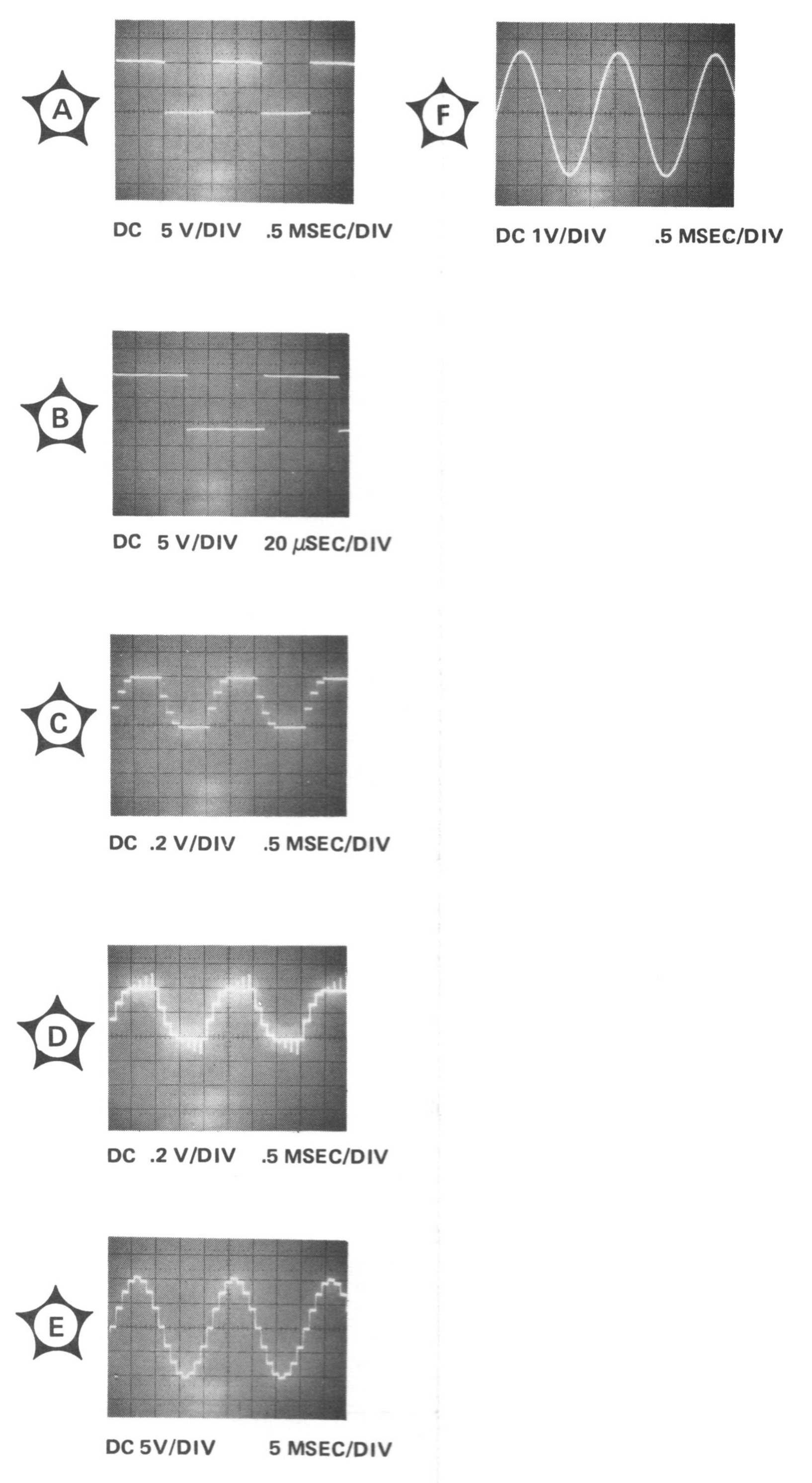


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Figure 7-27. Calibrator Circuit, Schematic Diagram (Part of PCA A7)

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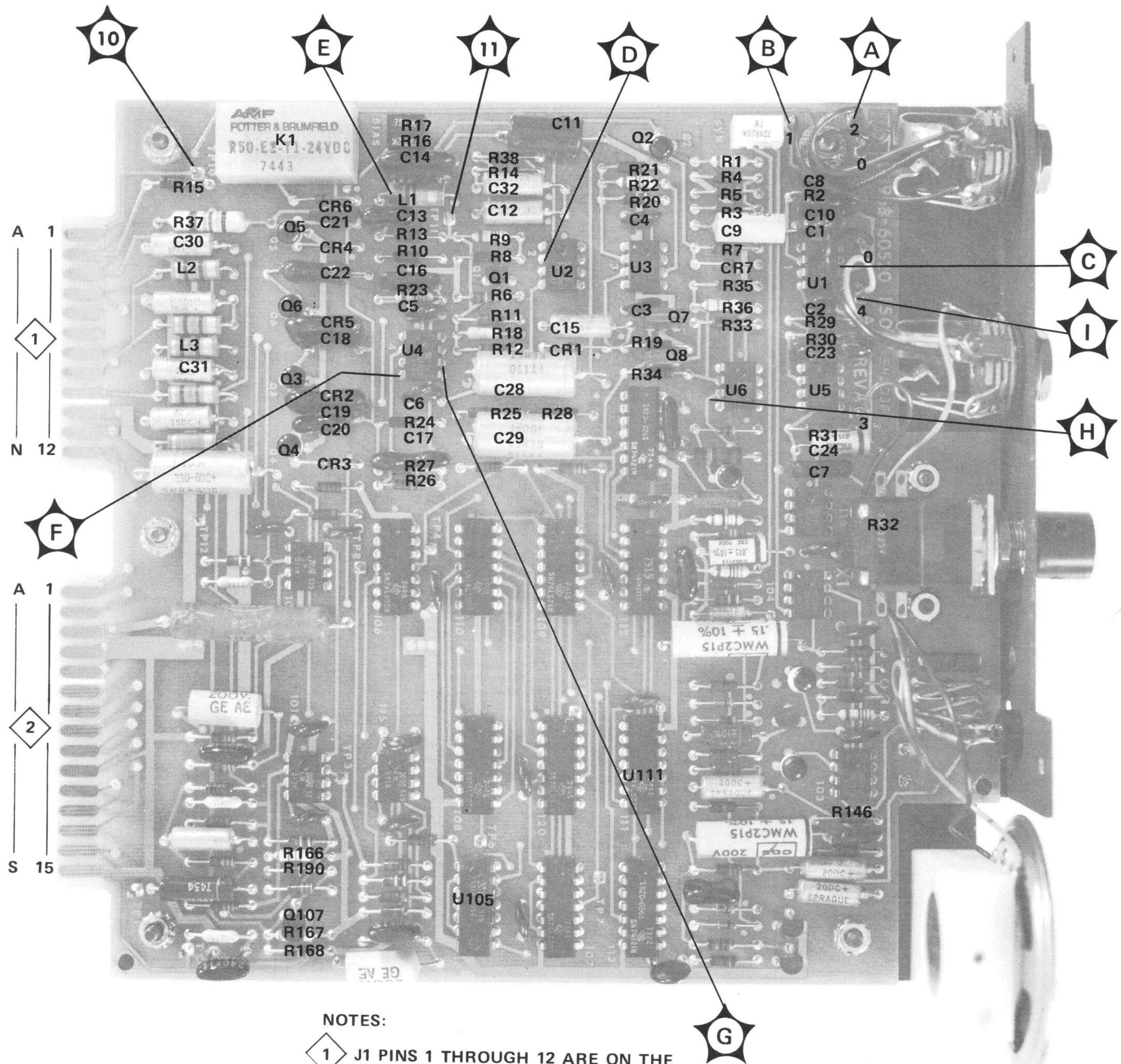
Figure 7-28. Voice Record/Reproduce Circuits, Servicing Diagram

Table 7-10. Voice Channel Circuit, Parts List (Part of PCA A8)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A8	03968-60520	1	VOICE CHANNEL/SERVO LOOP, PCA	28480	03968-60520
A8C1	0160-2055	23	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C2	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C3	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C4	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C5	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C6	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A8C7	0160-0174	4	CAPACITOR-FXD .47UF +80-20% 25WVDC CER	28480	0160-0174
A8C8	0160-0174		CAPACITOR-FXD .47UF +80-20% 25WVDC CER	28480	0160-0174
A8C9	0160-2672	1	CAPACITOR-FXD .047UF +-5% 80WVDC POLYE	56289	292P4735R8
A8C10	0160-0174		CAPACITOR-FXD .47UF +80-20% 25WVDC CER	28480	0160-0174
A8C11	0160-0164	1	CAPACITOR-FXD .039UF +-10% 200WVDC POLYE	56289	292P39392
A8C12	0180-0100	3	CAPACITOR-FXD 4.7UF+-10% 35VDC TA	56289	150D475X9035B2
A8C13	0160-0362	1	CAPACITOR-FXD 510PF +-5% 300WVDC MICA	28480	0160-0362
A8C14	0160-2216	1	CAPACITOR-FXD 820PF +-5% 300WVDC MICA	28480	0160-2216
A8C15	0180-0106	1	CAPACITOR-FXD 60UF+-20% 6VDC TA	56289	150D606X0006B2
A8C16	0160-0174		CAPACITOR-FXD .47UF +80-20% 25WVDC CER	28480	0160-0174
A8C17	0160-3289	1	CAPACITOR-FXD 560PF +-1% 100WVDC MICA	28480	0160-3289
A8C18	0160-2220	1	CAPACITOR-FXD 1200PF +-5% 300WVDC MICA	28480	0160-2220
A8C19	0160-2226	1	CAPACITOR-FXD 2200PF +-5% 300WVDC MICA	28480	0160-2226
A8C20	0160-2208	1	CAPACITOR-FXD 330PF +-5% 300WVDC MICA	28480	0160-2208
A8C21	0160-3450	1	CAPACITOR-FXD 5000PF +-10% 250WVDC CER	28480	0160-3450
A8C22	0160-0207	1	CAPACITOR-FXD .01UF +-5% 200WVDC POLYE	56289	292P10352
A8C23	0160-2218	1	CAPACITOR-FXD 1000PF +-5% 300WVDC MICA	28480	0160-2218
A8C24	0160-0194	2	CAPACITOR-FXD .015UF +-10% 200WVDC POLYE	56289	292P15392
A8C28	0180-0098	2	CAPACITOR-FXD 100UF+-20% 20VDC TA	56289	150D107X0020B2
A8C29	0180-0098		CAPACITOR-FXD 100UF+-20% 20VDC TA	56289	150D107X0020B2
A8C30	0180-0228	4	CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A8C31	0180-0228		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A8C32	0180-0100		CAPACITOR-FXD 4.7UF+-10% 35VDC TA	56289	150D475X9035B2
A8CR1	1901-0040	16	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR2	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR3	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR4	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR5	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR6	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR7	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A8CR111	1990-0534	1	LED-VISIBLE LUM-INT=2.2MCD IF=20MA-MAX	28480	1990-0534
A8K1	0490-0619	1	RELAY 1C 24VDC-COIL 2A 28VDC	28480	0490-0619
A8L1	9100-1649	1	COIL-MLD 620UH 5% Q=60 .19DX.44LG	24226	19/623
A8L2	9100-1620	4	COIL-MLD 15UH 10% Q=65 .155DX.375LG	24226	15/152
A8L3	9100-1620		COIL-MLD 15UH 10% Q=65 .155DX.375LG	24226	15/152
A8Q1	1854-0071	2	TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A8Q2	1855-0223	8	TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
A8Q3	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
A8Q4	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
A8Q5	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
A8Q6	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
A8Q7	1853-0073	1	TRANSISTOR PNP SI PD=25W FT=3MHZ	28480	1853-0073
A8Q8	1854-0300	1	TRANSISTOR NPN SI PD=25W FT=4MHZ	28480	1854-0300
A8Q107	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A8R1	0757-0458	6	RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A8R2	0757-0460	2	RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
A8R3	0757-0274	2	RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1213-F
A8R4	0757-0290	3	RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A8R5	0757-0441	2	RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F
A8R6	0757-0460		RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
A8R7	0757-0446	1	RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A8R8	0757-0280	4	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A8R9	0757-0458		RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A8R10	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A8R11	0757-0283	6	RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
A8R12	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
A8R13	0757-0427	2	RESISTOR 1.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1501-F
A8R14	0757-0427		RESISTOR 1.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1501-F
A8R15	0757-0401	4	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A8R16	0757-0407	1	RESISTOR 200 1% .125W F TC=0+-100	24546	C4-1/8-T0-201-F
A8R17	2100-2521	1	RESISTOR-TRMR 2K 10% C SIDE-ADJ 1-TRN	30983	ET50X202
A8R18	0757-0422	1	RESISTOR 909 1% .125W F TC=0+-100	24546	C4-1/8-T0-909R-F
A8R19	0757-0472	1	RESISTOR 200K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2003-F
A8R20	0757-0288	2	RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F

Table 7-10. Voice Channel Circuit, Parts List (Part of PCA A8) (Continued)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A8R21	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A8R22	0757-0458		RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A8R23	0757-0458		RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
A8R24	0698-3159	2	RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F
A8R25	0757-0420	2	RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
A8R26	0698-3159		RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F
A8R27	0757-0420		RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
A8R28	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
A8R29	0757-0278	1	RESISTOR 1.78K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1781-F
A8R30	0757-0449	1	RESISTOR 20K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2002-F
A8R31	0757-0465	2	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A8R32	2100-3467	1	RESISTOR-VAR W/SW 100K 10% LIN	28480	2100-3467
A8R33	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A8R34	0757-0274		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1213-F
A8R35	0757-0418	1	RESISTOR 619 1% .125W F TC=0+-100	24546	C4-1/8-T0-619R-F
A8R36	0757-0279	2	RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A8R37	0757-0003	1	RESISTOR 26.1 1% .5W F TC=0+-100	19701	MF7C1/2-T0-26R1-F
A8R38	0757-0442	4	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A8R146	0698-3441	1	RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A8R167	0757-0279		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A8R168	0757-0290		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A8R190	0757-0290		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A8U1	1820-0493	9	IC LM 307 OP AMP	27014	LM307N
A8U2	1820-0493		IC LM 307 OP AMP	27014	LM307N
A8U3	1820-0493		IC LM 307 OP AMP	27014	LM307N
A8U4	1820-0493		IC LM 307 OP AMP	27014	LM307N
A8U5	1820-0493		IC LM 307 OP AMP	27014	LM307N
A8U6	1820-0493		IC LM 307 OP AMP	27014	LM307N
A8U105	1820-0054		IC-DIGITAL SN7400N TTL QUAD 2 NAND	01295	SN7400N
A8U111	1820-1197		IC-DIGITAL SN74LS00N TTL LS QUAD 2 NAND	01295	SN74LS00N
			A8 MISCELLANEOUS		
	0360-1514	19	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
	0362-0227	8	TERMINAL-CRIMP QDISC-FEM 30-24-AWG	28480	0362-0227
	0370-0473	1	KNOB:ROUND	28480	0370-0473
	0380-0917	6	SPACER-RND .125LG .115ID .250D FBR	06540	9222
	2190-0108	2	WASHER-LK HLCL NO.-4 .115-IN-ID	28480	2190-0108
	2190-0163	2	WASHER-LK INTL T NO.-3/8 .38-IN-ID	78189	1220-05
	2190-0356	4	WASHER-SHLDR NO. 3/8 .38 IN ID .625 IN	15202	6529
	2200-0143	2	SCREW-MACH 4-40 .375-IN-LG PAN-HD-POZI	28480	2200-0143
	2260-0009	6	NUT-HEX-W/LKWR 4-40-THD .094-THK .25-A/F	28480	2260-0011
	2950-0001	2	NUT-HEX-DBL-CHAM 3/8-32-THD .094-THK	28480	2950-0030
	3030-0007	2	SCREW-SET 4-40 .125-IN-LG SMALL CUP-PT	28480	3030-0007
	8150-0296		WIRE 24AWG V 1000V PVC 7X32 105C	28480	8150-0296
	8150-0297		WIRE 24AWG BL 1000V PVC 7X32 105C	28480	8150-0297
	8150-0298		WIRE 24AWG G 1000V PVC 7X32 105C	28480	8150-0298
	8150-0299		WIRE 24AWG Y 1000V PVC 7X32 105C	28480	8150-0299
	8150-0300		WIRE 24AWG O 1000V PVC 7X32 105C	28480	8150-0300
	8150-0301		WIRE 24AWG R 1000V PVC 7X32 105C	28480	8150-0301
	8150-0303		WIRE 24AWG BK 1000V PVC 7X32 105C	28480	8150-0303
	9160-0243	1	SPEAKER CONE 2" DIA Z=80 NM	50811	25SP002
	5000-0477	1	INSERT DIAL	28480	5000-0477
	03968-00221	1	VOICE SHIELD, MARKER	28480	03968-00221
	03968-00530	1	MOUNT, POT	28480	03968-00530
	03968-20220	1	BASE, SPEAKER	28480	03968-20220



NOTES:

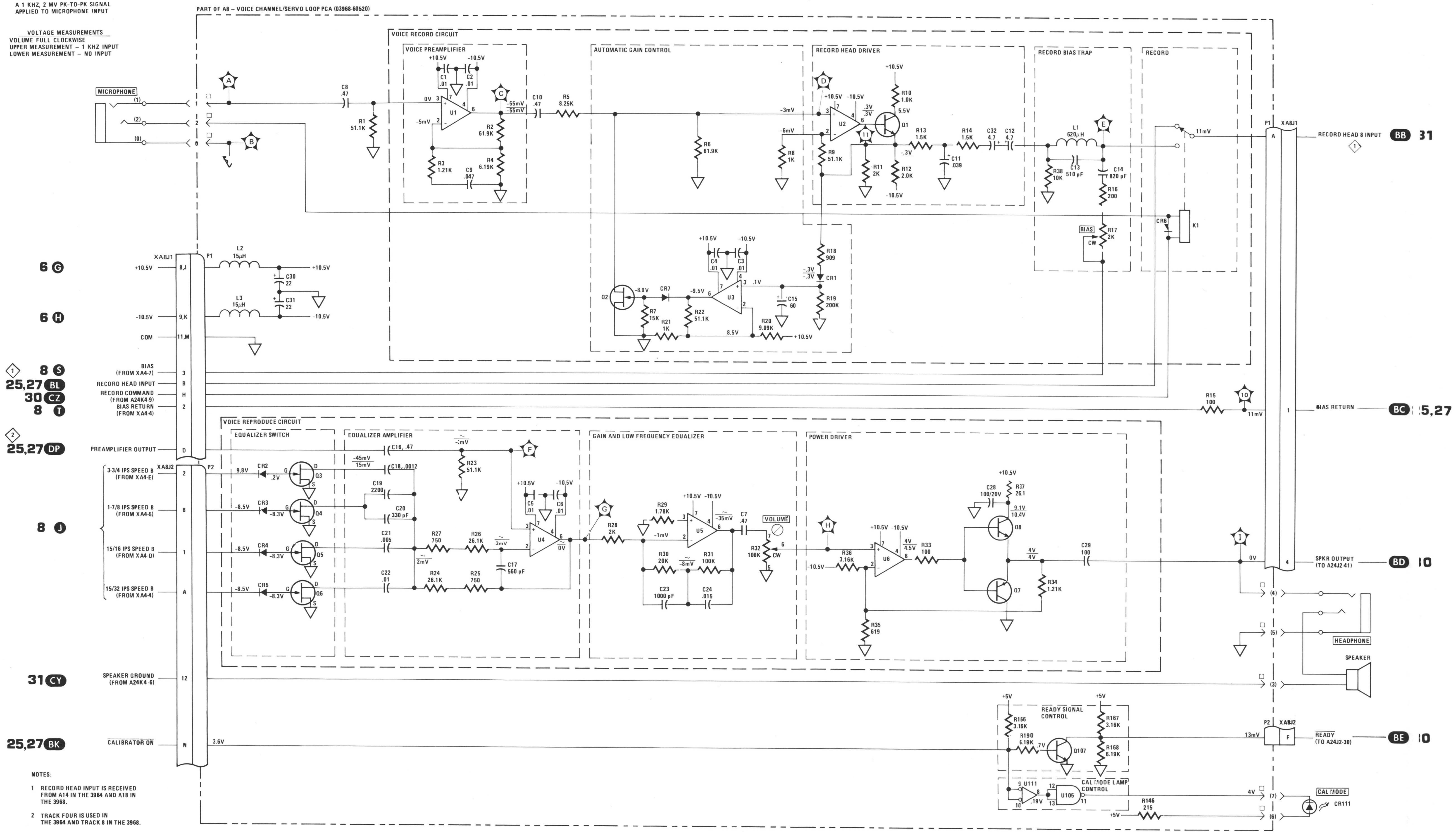
1. J1 PINS 1 THROUGH 12 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH N ARE ON THE REVERSE SIDE.

2. J2 PINS 1 THROUGH 15 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH S ARE ON THE REVERSE SIDE.

Figure 7-29. Voice Record/Reproduce Circuit, Parts Location (Part of PCA A8)

WAVEFORM MEASUREMENTS
A 1 KHZ, 2 MV PK-TO-PK SIGNAL APPLIED TO MICROPHONE INPUT

VOLTAGE MEASUREMENTS
VOLUME FULL CLOCKWISE
UPPER MEASUREMENT – 1 KHZ INPUT
LOWER MEASUREMENT – NO INPUT



NOTES:

1. RECORD HEAD INPUT IS RECEIVED FROM A14 IN THE 3964 AND A18 IN THE 3968.
2. TRACK FOUR IS USED IN THE 3964 AND TRACK 8 IN THE 3968.

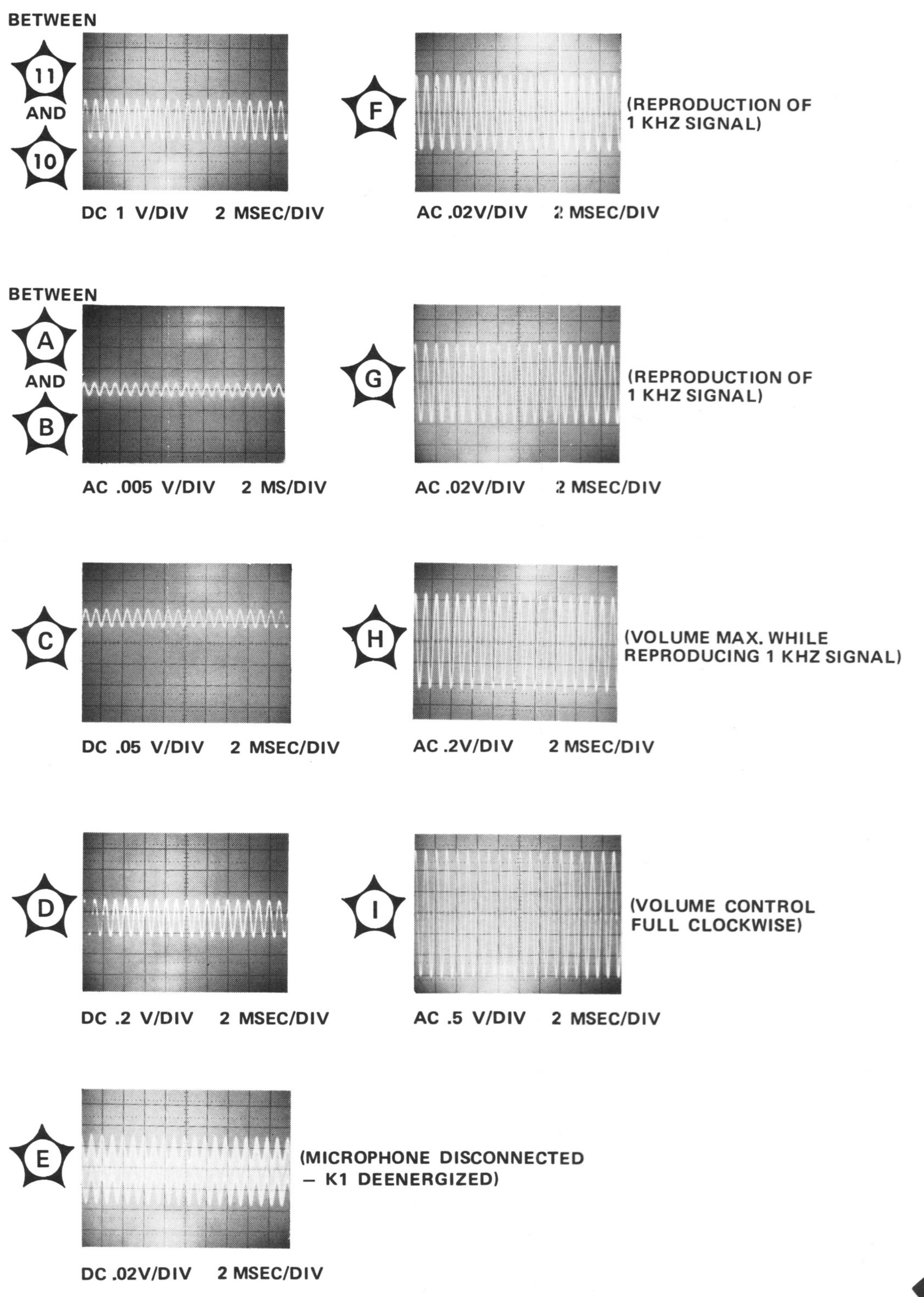


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Figure 7-30. Voice Record/Reproduce Circuit, Schematic Diagram (Part of PCA A8)

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Figure 7-31. Overlap Circuit (Option 070), Servicing Diagram

Table 7-11. Overlap PCA A9 (Option 070), Parts List

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A9	03968-60470	1	OVERLAP, PCA (OPTION 070)	28480	03968-60470
A9C1	0180-0228	3	CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A9C2	0180-0106	2	CAPACITOR-FXD 60UF+-20% 6VDC TA	56289	150D606X0006B2
A9C3	0180-0228		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A9C4	0180-0210	1	CAPACITOR-FXD 3.3UF+-20% 15VDC TA	56289	150D335X0015A2
A9C5	0160-2055	11	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A9C6	0170-0040	3	CAPACITOR-FXD .047UF +-10% 200WVDC POLYE	56289	292P47392
A9C7	0160-3449	1	CAPACITOR-FXD 2000PF +-10% 250WVDC CER	28480	0160-3449
A9C8	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A9C9	0160-2047	1	CAPACITOR-FXD 5PF +-.5PF 500WVDC MICA	28480	0160-2047
A9C10	0150-0059	1	CAPACITOR-FXD 3.3PF +-.25PF 500WVDC CER	28480	0150-0059
A9C11	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A9C12	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A9C13	0150-0121	1	CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
A9C14	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A9C15	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A9C16	0170-0040		CAPACITOR-FXD .047UF +-10% 200WVDC POLYE	56289	292P47392
A9C17	0180-0228		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A9C18	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A9C19	0180-0106		CAPACITOR-FXD 60UF+-20% 6VDC TA	56289	150D606X0006B2
A9C20	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A9C21	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A9C22	0170-0040		CAPACITOR-FXD .047UF +-10% 200WVDC POLYE	56289	292P47392
A9C23	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A9C24	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A9CR1	1901-0040	3	DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A9CR2	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A9CR3	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A9L1	9100-1620	1	COIL-FXD MOLDED RF CHOKE 15UH 10%	24226	15/152
A9Q1	1854-0467	1	TRANSISTOR NPN 2N4401 SI TO-92 PD=310MW	04713	2N4401
A9Q2	1854-0215	2	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A9Q3	1854-0215		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
A9R1	0757-0422	1	RESISTOR 909 1% .125W F TC=0+-100	24546	C4-1/8-T0-909R-F
A9R2	0757-0346	1	RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A9R3	0757-0442	3	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A9R4	0757-0460	4	RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
A9R5	0757-0460		RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
A9R6	0757-0418	1	RESISTOR 619 1% .125W F TC=0+-100	24546	C4-1/8-T0-619R-F
A9R7	0757-0465	2	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A9R8	0757-0482	1	RESISTOR 511K 1% .125W F TC=0+-100	24546	NA4
A9R9	2100-3274	1	RESISTOR-TRMR 10K 10% C SIDE-ADJ	32997	3386X-Y46-103
A9R10	0698-3151	1	RESISTOR 2.87K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2871-F
A9R11	0757-0438	1	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A9R12	0757-0460		RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
A9R13	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A9R14	0757-0123	1	RESISTOR 34.8K 1% .125W F TC=0+-100	24546	C5-1/4-T0-3482-F
A9R15	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A9R16	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A9R17	0757-0460		RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
A9R18	0698-3266	1	RESISTOR 237K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2373-F
A9R19	2100-3358	1	RESISTOR-TRMR 1M 20% C SIDE-ADJ 1-TRN	32997	3386X-Y46-105
A9R20	1810-0136	1	NETWORK-RES 10-PIN-SIP .1-PIN-SPCG	28480	1810-0136
A9R34	0757-0379	1	RESISTOR 12.1 1% .125W F TC=0+-100	19701	MF4C1/8-T0-12R1-F
A9R35	0698-3438	1	RESISTOR 147 1% .125W F TC=0+-100	16299	C4-1/8-T0-147R-F
A9U1	1826-0180	2	IC NE 555 TIMER	18324	NE555V
A9U2	1820-0477	1	IC LM 301A OP AMP	27014	LM301AN
A9U3	1826-0138	1	IC LM 339 COMPARATOR	27014	LM339N
A9U4	1820-0261	2	IC SN74 121 N MV	01295	SN74121N
A9U5	1820-0583	1	IC DM74L 00N GATE	27014	DM74L00N
A9U6	1820-0327	1	IC:TTL QUAD 2-INPT NAND GATE	01295	SN7401N
A9U7	1826-0180		IC NE 555 TIMER	18324	NE555V
A9U8	1820-0261		IC SN74 121 N MV	01295	SN74121N
			A9 MISCELLANEOUS		
	0360-0417	2	TERMINAL STRIP 2-TERM PHEN 1.125-IN-L	71785	332-11-03-028
	0360-1514	6	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
	0380-0917	4	STANDOFF-RND .125LG .115ID .250D FBR	06540	9222
A9Z4	4330-0145		INSULATOR-BEAD .031-ID	28480	4330-0145

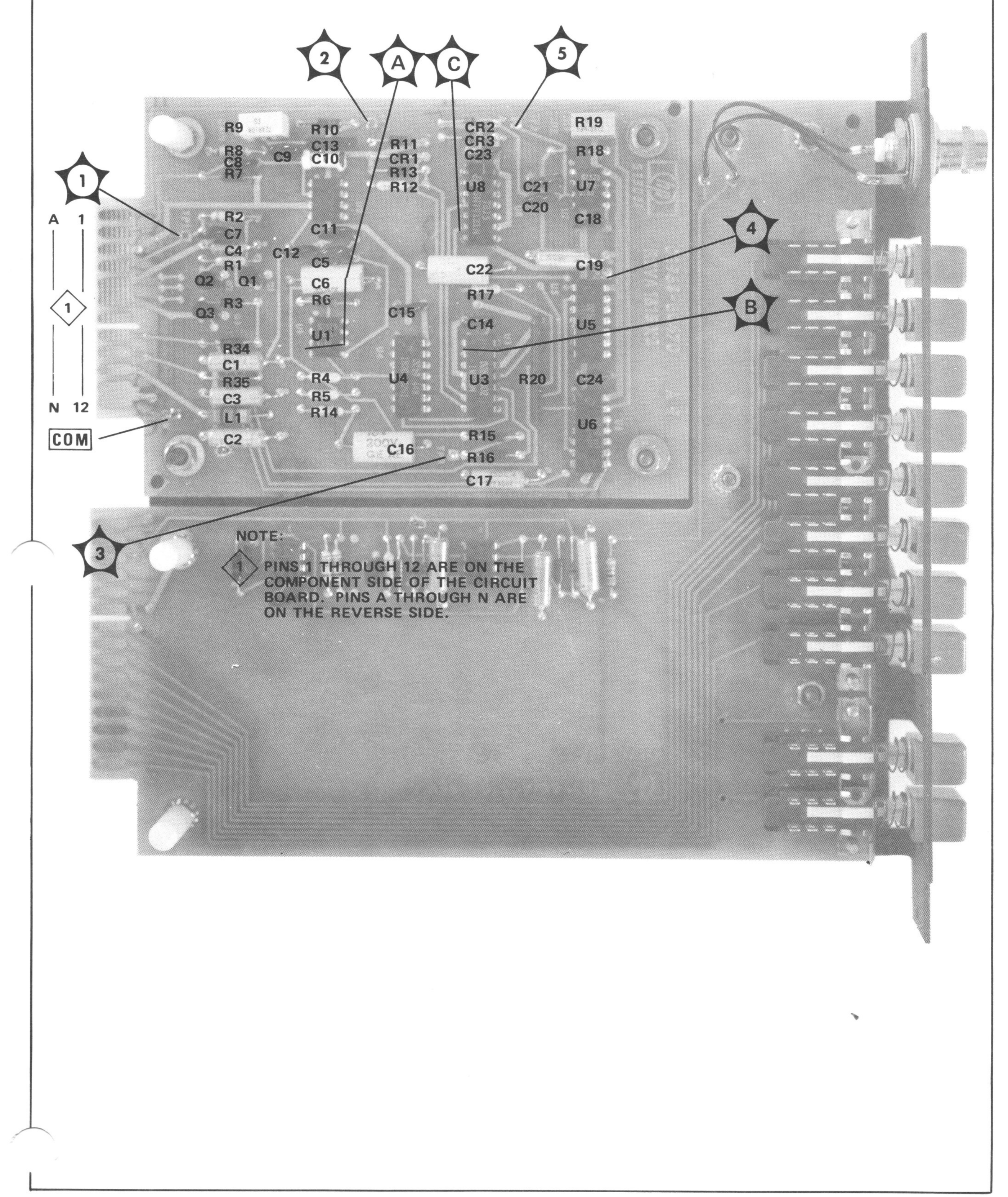

Figure 7-32. Overlap PCA A9 (Option 070), Parts Location

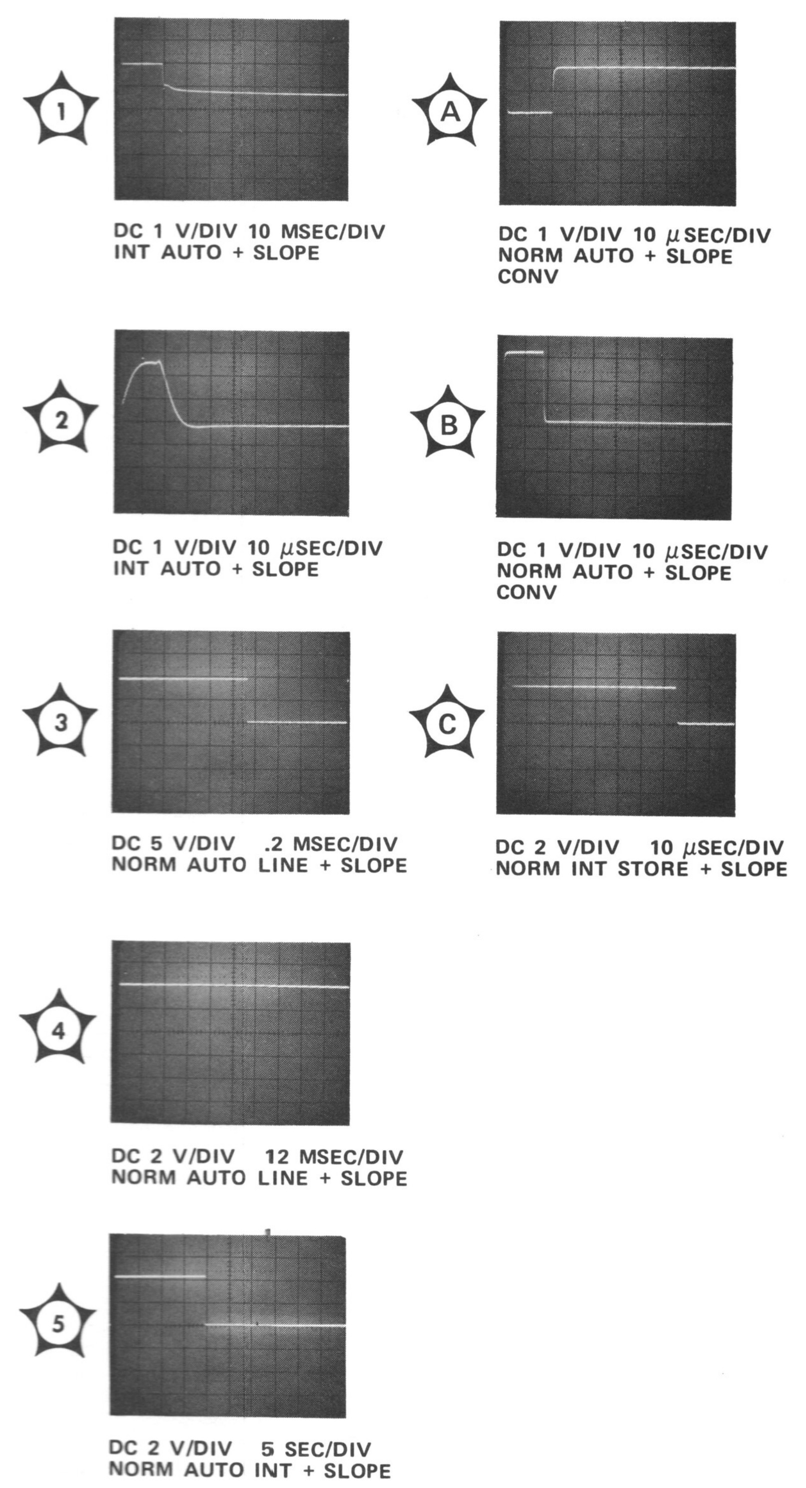

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Figure 7-33. Overlap PCA A9 (Option 070), Schematic Diagram

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Figure 7-34. FM Record/Reproduce Circuits (Option 001), Servicing Diagram

Table 7-12. 3964A Preamplifier PCA A10, Parts List

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A10	03964-60590	1	PCA, PREAMPLIFIER	28480	03964-60590
C1	0180-1747	2	CAPACITOR-FXD 150UF+-20% 15VDC TA	56289	150D157X0015
C2	0180-1747		CAPACITOR-FXD 150UF+-20% 15VDC TA	56289	150D157X0015
C201	0160-2019	4	CAPACITOR-FXD 270PF +-5% 500WVDC MICA	28480	0160-2019
C202	0160-2055	4	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C203	0160-2243	4	CAPACITOR-FXD 2.7PF +-.25PF 500WVDC CER	28480	0160-2243
C401	0160-2019		CAPACITOR-FXD 270PF +-5% 500WVDC MICA	28480	0160-2019
C402	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C403	0160-2243		CAPACITOR-FXD 2.7PF +-.25PF 500WVDC CER	28480	0160-2243
C601	0160-2019		CAPACITOR-FXD 270PF +-5% 500WVDC MICA	28480	0160-2019
C602	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C603	0160-2243		CAPACITOR-FXD 2.7PF +-.25PF 500WVDC CER	28480	0160-2243
C801	0160-2019		CAPACITOR-FXD 270PF +-5% 500WVDC MICA	28480	0160-2019
C802	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C803	0160-2243		CAPACITOR-FXD 2.7PF +-.25PF 500WVDC CER	28480	0160-2243
CR201	1901-0040	4	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR401	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR601	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR801	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
Q201	1854-0515	4	TRANSISTOR-DUAL NPN TO-77 PD=600MW	28480	1854-0515
Q401	1854-0515		TRANSISTOR-DUAL NPN TO-77 PD=600MW	28480	1854-0515
Q601	1854-0515		TRANSISTOR-DUAL NPN TO-77 PD=600MW	28480	1854-0515
Q801	1854-0515		TRANSISTOR-DUAL NPN TO-77 PD=600MW	28480	1854-0515
R1	0757-0401	6	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
R2	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
R104	0698-0085	4	RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
R105	0757-0462	4	RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
R201	0757-0446	12	RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R202	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R203	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R206	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
R305	0757-0462		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
R401	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R402	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R403	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R404	0698-0085		RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
R406	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
R505	0757-0462		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
R601	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R602	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R603	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R604	0698-0085		RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
R606	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
R705	0757-0462		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
R801	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R802	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R803	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R804	0698-0085		RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
R806	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
U301	1826-0139	2	IC MC 1458 OP AMP	04713	MC1458P1
U501	1826-0139		IC MC 1458 OP AMP	04713	MC1458P1
			MISCELLANEOUS		
	0360-1514	8	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
	0360-1552	9	TERMINAL-STUD SGL-PIN PRESS-MTG	88245	7713-7
	1200-0767	1	SOCKET-IC 16-CONT DIP-SLDR-TERMS	91506	316-AG5D 3R
	03968-20060	1	SPACER, MALE	28480	03968-20060
	03968-20061	1	SPACER, FEMALE	28480	03968-20061

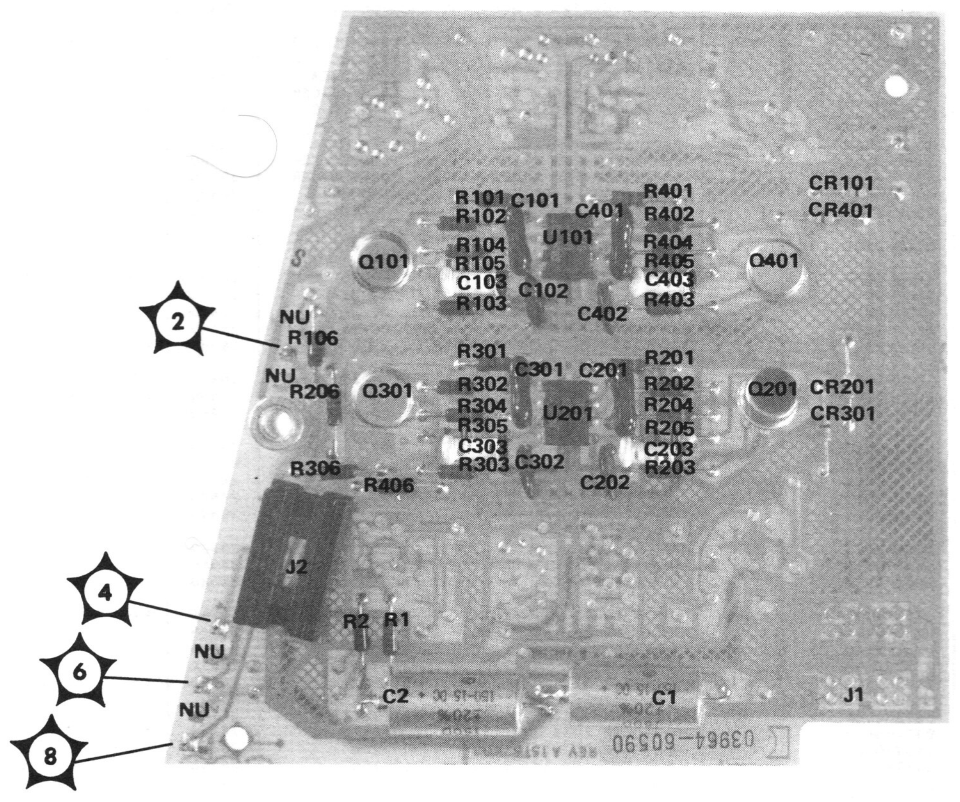

Figure 7-35. 3964A Preamplifier PCA A10, Parts Location

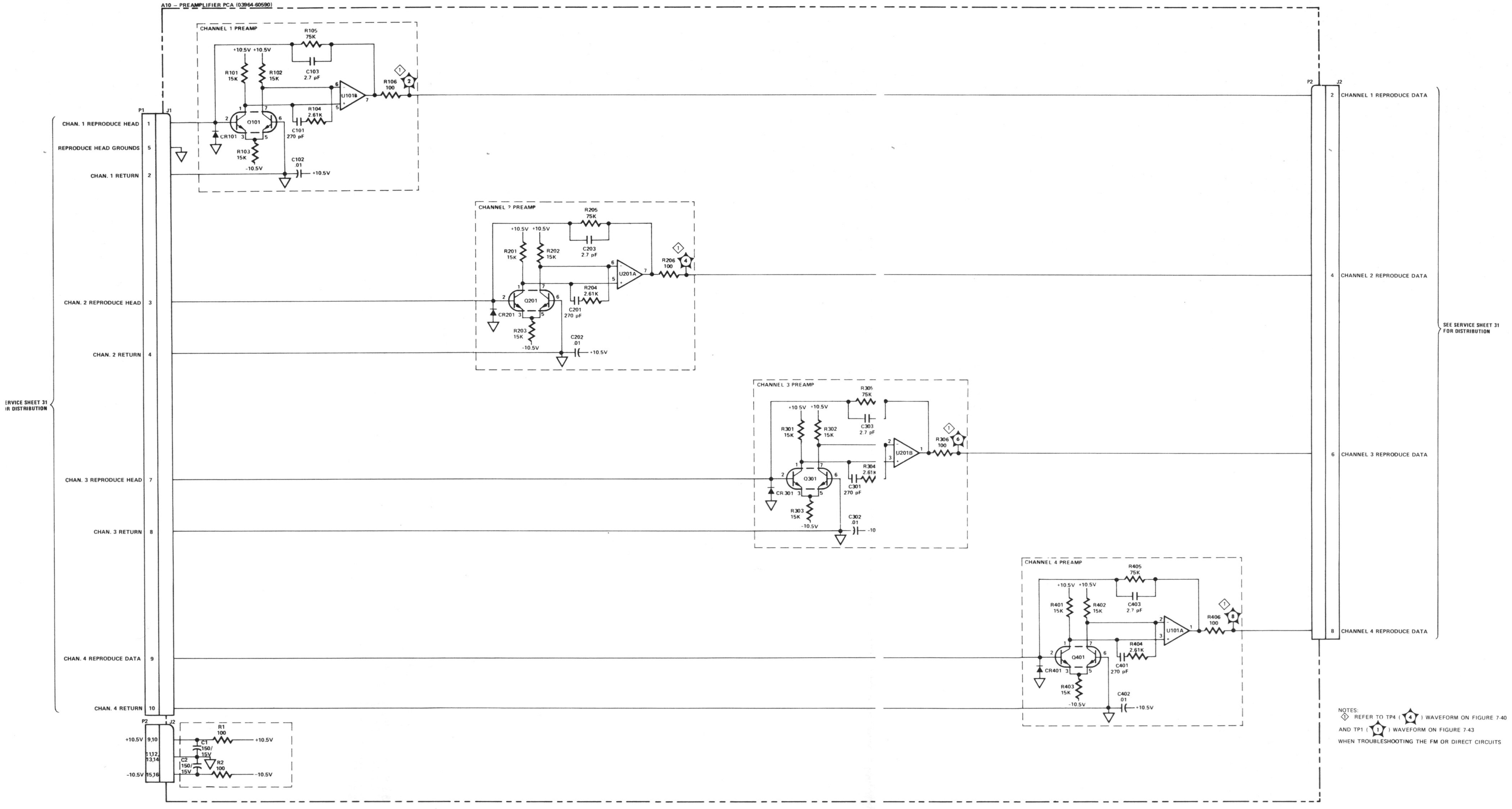

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Figure 7-36. 3964A Preamplifier PCA A10, Schematic Diagram

Table 7-13. 3968A Preamplifier PCA A10, Parts List

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A10	03968-60590	1	PREAMPLIFIER, PCA	28480	03968-60590
A10C1	0180-1747	2	CAPACITOR-FXD 150UF+-20% 15VDC TA	56289	150D157X0015
A10C2	0180-1747		CAPACITOR-FXD 150UF+-20% 15VDC TA	56289	150D157X0015
A10C101	0160-2019	8	CAPACITOR-FXD 270PF +-5% 500WVDC MICA	28480	0160-2019
A10C102	0160-2055	8	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A10C103	0160-2243	8	CAPACITOR-FXD 2.7PF +-.25PF 500WVDC CER	28480	0160-2243
A10C201	0160-2019		CAPACITOR-FXD 270PF +-5% 500WVDC MICA	28480	0160-2019
A10C202	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A10C203	0160-2243		CAPACITOR-FXD 2.7PF +-.25PF 500WVDC CER	28480	0160-2243
A10C301	0160-2019		CAPACITOR-FXD 270PF +-5% 500WVDC MICA	28480	0160-2019
A10C302	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A10C303	0160-2243		CAPACITOR-FXD 2.7PF +-.25PF 500WVDC CER	28480	0160-2243
A10C401	0160-2019		CAPACITOR-FXD 270PF +-5% 500WVDC MICA	28480	0160-2019
A10C402	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A10C403	0160-2243		CAPACITOR-FXD 2.7PF +-.25PF 500WVDC CER	28480	0160-2243
A10C501	0160-2019		CAPACITOR-FXD 270PF +-5% 500WVDC MICA	28480	0160-2019
A10C502	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A10C503	0160-2243		CAPACITOR-FXD 2.7PF +-.25PF 500WVDC CER	28480	0160-2243
A10C601	0160-2019		CAPACITOR-FXD 270PF +-5% 500WVDC MICA	28480	0160-2019
A10C602	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A10C603	0160-2243		CAPACITOR-FXD 2.7PF +-.25PF 500WVDC CER	28480	0160-2243
A10C701	0160-2019		CAPACITOR-FXD 270PF +-5% 500WVDC MICA	28480	0160-2019
A10C702	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A10C703	0160-2243		CAPACITOR-FXD 2.7PF +-.25PF 500WVDC CER	28480	0160-2243
A10C801	0160-2019		CAPACITOR-FXD 270PF +-5% 500WVDC MICA	28480	0160-2019
A10C802	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A10C803	0160-2243		CAPACITOR-FXD 2.7PF +-.25PF 500WVDC CER	28480	0160-2243
A10CR101	1901-0040	8	DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A10CR201	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A10CR301	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A10CR401	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A10CR501	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A10CR601	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A10CR701	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A10CR801	1901-0040		DIODE-SWITCHING 30V 50NA 2NS DO-35	28480	1901-0040
A10Q101	1854-0515	8	TRANSISTOR-DUAL NPN TO-77 PD=600MW	28480	1854-0515
A10Q201	1854-0515		TRANSISTOR-DUAL NPN TO-77 PD=600MW	28480	1854-0515
A10Q301	1854-0515		TRANSISTOR-DUAL NPN TO-77 PD=600MW	28480	1854-0515
A10Q401	1854-0515		TRANSISTOR-DUAL NPN TO-77 PD=600MW	28480	1854-0515
A10Q501	1854-0515		TRANSISTOR-DUAL NPN TO-77 PD=600MW	28480	1854-0515
A10Q601	1854-0515		TRANSISTOR-DUAL NPN TO-77 PD=600MW	28480	1854-0515
A10Q701	1854-0515		TRANSISTOR-DUAL NPN TO-77 PD=600MW	28480	1854-0515
A10Q801	1854-0515		TRANSISTOR-DUAL NPN TO-77 PD=600MW	28480	1854-0515
A10R1	0757-0401	10	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A10R2	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A10R101	0757-0446	24	RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R102	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R103	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R104	0698-0085	8	RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
A10R105	0757-0465	8	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A10R106	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A10R201	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R202	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R203	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R204	0698-0085		RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
A10R205	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A10R206	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A10R301	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R302	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R303	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R304	0698-0085		RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
A10R305	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A10R306	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A10R401	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R402	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R403	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R404	0698-0085		RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
A10R405	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A10R406	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A10R501	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R502	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R503	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R504	0698-0085		RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F

Table 7-13. 3968A Preamplifier PCA A10, Parts List (Continued)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A10R505	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A10R506	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A10R601	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R602	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R603	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R604	0698-0085		RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
A10R605	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A10R606	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A10R701	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R702	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R703	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R704	0698-0085		RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
A10R705	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A10R706	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A10R801	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R802	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R803	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
A10R804	0698-0085		RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
A10R805	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A10R806	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A10U1	1826-0139	6	IC MC 1458 OP AMP	04713	MC1458P1
A10U2	1826-0139		IC MC 1458 OP AMP	04713	MC1458P1
A10U3	1826-0139		IC MC 1458 OP AMP	04713	MC1458P1
A10U301	1826-0139		IC MC 1458 OP AMP	04713	MC1458P1
A10U501	1826-0139		IC MC 1458 OP AMP	04713	MC1458P1
A10U701	1826-0139		IC MC 1458 OP AMP	04713	MC1458P1
	0360-1514	8	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
	0360-1552	16	TERMINAL-STUD SGL-PIN PRESS-MTG	88245	7713-7
	1200-0767	1	SOCKET-IC 16-CONT DIP-SLDR-TERMS	91506	316-AG5D-3R
	03968-20060	1	SPACER, MALE	28480	03968-20060
	03968-20061	1	SPACER, FEMALE	28480	03968-20061

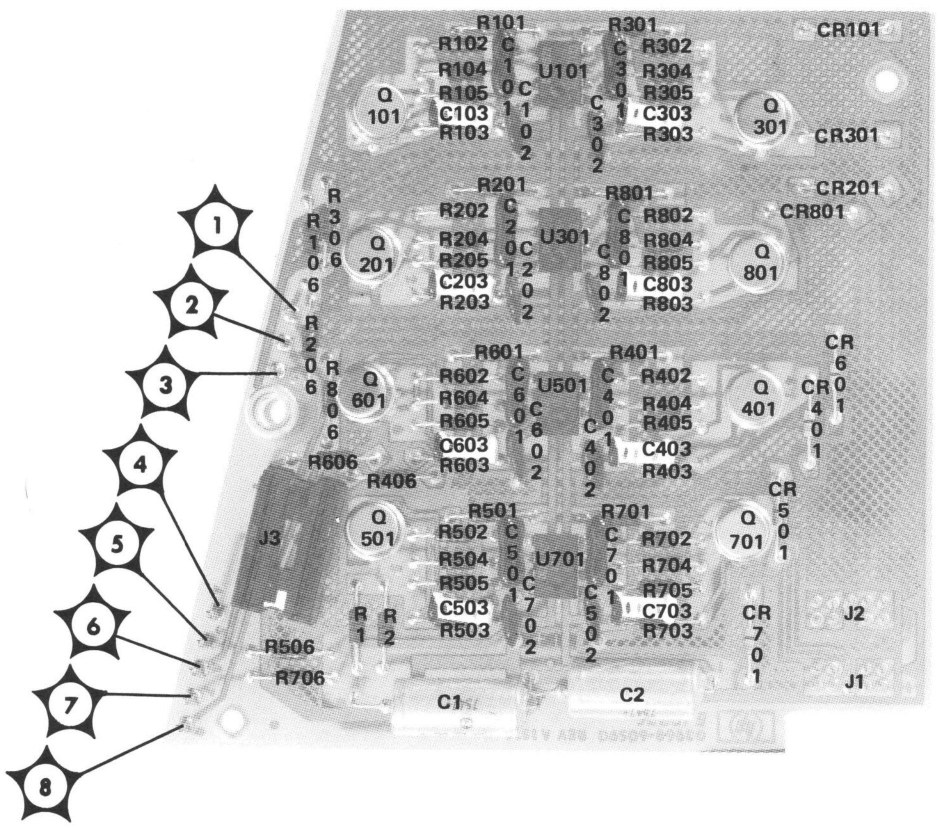
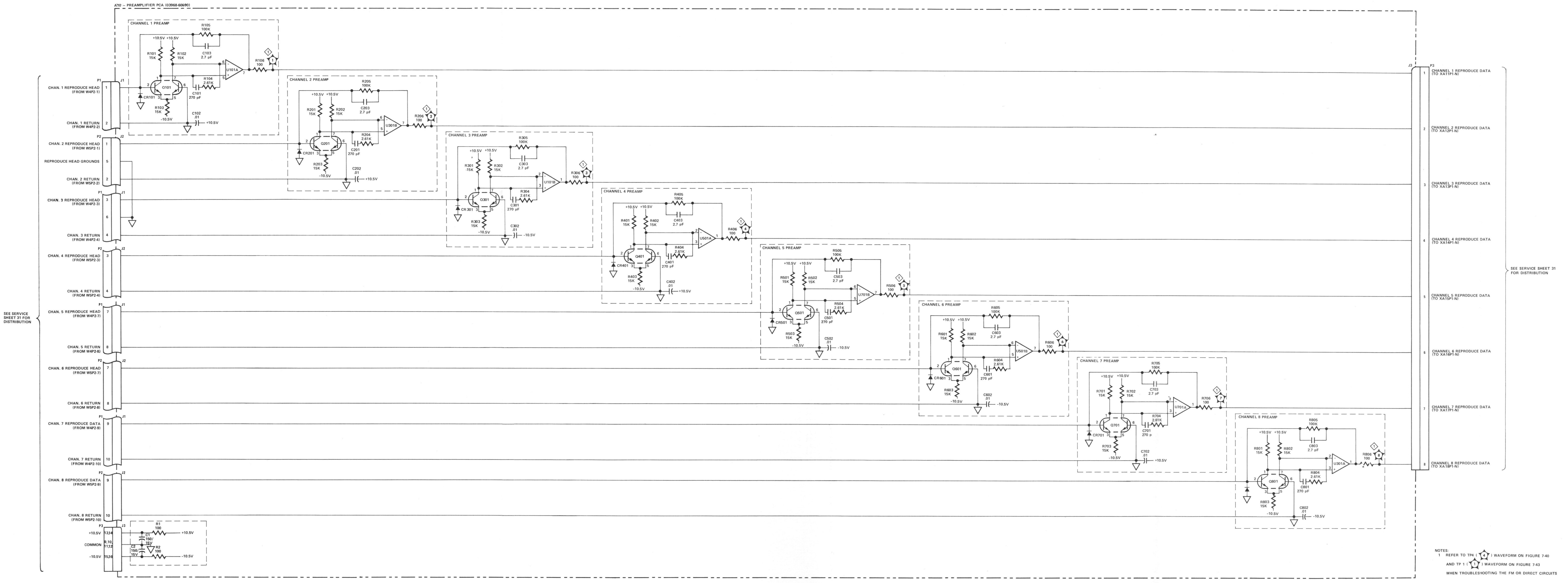


Figure 7-37. 3968A Preamplifier PCA A10, Parts Location



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SERVICE SHEET

Figure 7-38. 3968A Preamplifier PCA A10, Schematic Diagram

Table 7-14. FM Record/Reproduce PCA, Parts List

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A11–A14 (3964A) A11–A18 (3968A)	03964-60505		PCA, FM RECORD/REPRODUCE	28480	03964-60505
C1	0160-2204	1	CAPACITOR-FXD 100PF +-5% 300WVDC MICA	28480	0160-2204
C2	0160-2055	21	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C3	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C4	0160-0127	6	CAPACITOR-FXD 1UF +-20% 25WVDC CER	28480	0160-0127
C5	0160-0154	1	CAPACITOR-FXD 2200PF +-10% 200WVDC POLYE	56289	292P22292
C6	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C7	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C8	0180-0197	3	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
C9	0160-2585	2	CAPACITOR-FXD 2000PF +-1% 100WVDC MICA	28480	0160-2585
C10	0160-0127		CAPACITOR-FXD 1UF +-20% 25WVDC CER	28480	0160-0127
C11	0160-0127		CAPACITOR-FXD 1UF +-20% 25WVDC CER	28480	0160-0127
C12	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C13	0180-0116	1	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
C14	0160-0159	4	CAPACITOR-FXD 6800PF +-10% 200WVDC POLYE	56289	292P68292
C15	0160-0299	1	CAPACITOR-FXD 1800PF +-10% 200WVDC POLYE	56289	292P18292
C16	0160-2216	1	CAPACITOR-FXD 820PF +-5% 300WVDC MICA	28480	0160-2216
C18	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
C19	0180-1743	1	CAPACITOR-FXD .1UF+-10% 35VDC TA	56289	150D104X9035A2
C20	0160-0127		CAPACITOR-FXD 1UF +-20% 25WVDC CER	28480	0160-0127
C21	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C22	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C23	0160-2197	1	CAPACITOR-FXD 10PF +-5% 300WVDC MICA	28480	0160-2197
C24	0160-0157	1	CAPACITOR-FXD 4700PF +-10% 200WVDC POLYE	56289	292P47292
C25	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C26	0160-0155	2	CAPACITOR-FXD 3300PF +-10% 200WVDC POLYE	56289	292P33292
C27	0160-0300	1	CAPACITOR-FXD 2700PF +-10% 200WVDC POLYE	56289	292P27292
C28	0160-0159		CAPACITOR-FXD 6800PF +-10% 200WVDC POLYE	56289	292P68292
C29	0170-0066	2	CAPACITOR-FXD .027UF +-10% 200WVDC POLYE	56289	292P27392
C30	0160-0163	1	CAPACITOR-FXD .033UF +-10% 200WVDC POLYE	56289	292P33392
C31	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
C32	0160-0153	3	CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE	56289	292P10292
C33	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C34	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C35	0160-0153		CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE	56289	292P10292
C36	0160-0153		CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE	56289	292P10292
C37	0160-0155		CAPACITOR-FXD 3300PF +-10% 200WVDC POLYE	56289	292P33292
C38	0160-0159		CAPACITOR-FXD 6800PF +-10% 200WVDC POLYE	56289	292P68292
C39	0160-0194	1	CAPACITOR-FXD .015UF +-10% 200WVDC POLYE	56289	292P15392
C40	0170-0066		CAPACITOR-FXD .027UF +-10% 200WVDC POLYE	56289	292P27392
C41	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C42	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C43	0140-0199	1	CAPACITOR-FXD 240PF +-5% 300WVDC MICA	72136	DM15F241J0300WV1CR
C44	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C45	0160-2585		CAPACITOR-FXD 2000PF +-1% 100WVDC MICA	28480	0160-2585
C46	0160-0127		CAPACITOR-FXD 1UF +-20% 25WVDC CER	28480	0160-0127
C47	0160-4357	2	CAPACITOR-FXD .01UF +-2% 100WVDC	28480	0160-4357
C48	0160-2229	1	CAPACITOR-FXD 3000PF +-5% 300WVDC MICA	28480	0160-2229
C49	0160-4357		CAPACITOR-FXD .01UF +-2% 100WVDC	28480	0160-4357
C50	0160-2218	1	CAPACITOR-FXD 1000PF +-5% 300WVDC MICA	28480	0160-2218
C51	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055

Table 7-14. FM Record/Reproduce PCA, Parts List (Continued)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
C52	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C53	0160-4358	1	CAPACITOR-FXD .03UF +-2% 100WVDC	28480	0160-4358
C54	0160-0159		CAPACITOR-FXD 6800PF +-10% 200WVDC POLYE	56289	292P68292
C55	0160-2373	1	CAPACITOR-FXD 4700PF +-2% 300WVDC MICA	28480	0160-2373
C56	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C57	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C58	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C59	0160-0127		CAPACITOR-FXD 1UF +-20% 25WVDC CER	28480	0160-0127
C60	0160-2208	1	CAPACITOR-FXD 330PF +-5% 300WVDC MICA	28480	0160-2208
C61	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C62	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C63	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C70	0180-0228	4	CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X901582
C71	0180-0228		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X901582
C72	0180-0228		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X901582
C73	0180-0228		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X901582
C74	0180-1714	1	CAPACITOR-FXD 330UF+-10% 6VDC TA	56289	150D337X900682
CR1	1901-0376	2	DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
CR2	1901-0376		DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
CR3	1902-0041	1	DIODE-ZNR 5.11V 5% DO-7 PD=.4W TC=-.009%	15818	CD 35622
CR4	1901-0040	15	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR5	1902-3094	2	DIODE-ZNR 5.11V 2% DO-7 PD=.4W TC=-.009%	04713	SZ 10939-99
CR6	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR7	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR8	1902-3094		DIODE-ZNR 5.11V 2% DO-7 PD=.4W TC=-.009%	04713	SZ 10939-99
CR9	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR15	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR16	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR17	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR18	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR19	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR20	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR21	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR22	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR23	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR24	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR25	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR26	1902-0084	2	DIODE-ZNR 6.81V 5% DO-15 PD=1W TC=+.043%	28480	1902-0084
CR27	1902-0084		DIODE-ZNR 6.81V 5% DO-15 PD=1W TC=+.043%	28480	1902-0084
J1	1251-1122	1	CONNECTOR-SGL CONT SKT .08-IN-BSC-SZ RND	74970	105-0758-001
J2	1251-1123	1	CONNECTOR-SGL CONT SKT .08-IN-BSC-SZ RND	74970	105-0752-001
J3	1251-1124	1	CONNECTOR-SGL CONT SKT .08-DIA ORN POLYA	74970	105-756
K1	0490-0644	1	RELAY-REED C 100MA 250VAC 24VDC-COIL 4VA	28480	0490-0644
L1	9100-1661	1	COIL-MLD 2.2MH 5% Q=70 .215DX.56LG	24226	22/224
L2	9140-0098	1	COIL-MLD 2.2UH 10% Q=33 .155DX.375LG	24226	15/221
L3	9100-1620	4	COIL-MLD 15UH 10% Q=65 .155DX.375LG	24226	15/152
L4	9100-1620		COIL-MLD 15UH 10% Q=65 .155DX.375LG	24226	15/152
L5	9100-1620		COIL-MLD 15UH 10% Q=65 .155DX.375LG	24226	15/152
L6	9100-1620		COIL-MLD 15UH 10% Q=65 .155DX.375LG	24226	15/152
L7	9100-1619	1	COIL-MLD 6.8UH 10% Q=50 .155DX.375LG	24226	15/681
Q1	1853-0066	2	TRANSISTOR PNP SI TO-92 PD=625MW	28480	1853-0066
Q2	1853-0015	3	TRANSISTOR PNP SI PD=200MW FT=500MHZ	28480	1853-0015
Q3	1854-0094	4	TRANSISTOR NPN SI PD=200MW FT=350MHZ	28480	1854-0094
Q4	1854-0071	4	TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
Q5	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
Q6	1853-0036	1	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
Q7	1853-0015		TRANSISTOR PNP SI PD=200MW FT=500MHZ	28480	1853-0015
Q8	1854-0094		TRANSISTOR NPN SI PD=200MW FT=350MHZ	28480	1854-0094
Q10	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
Q11	1855-0223	30	TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q12	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q13	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q14	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q15	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q16	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q17	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q18	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q19	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q20	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q21	1854-0094		TRANSISTOR NPN SI PD=200MW FT=350MHZ	28480	1854-0094
Q22	1853-0066		TRANSISTOR PNP SI TO-92 PD=625MW	28480	1853-0066
Q23	1853-0015		TRANSISTOR PNP SI PD=200MW FT=500MHZ	28480	1853-0015
Q24	1854-0094		TRANSISTOR NPN SI PD=200MW FT=350MHZ	28480	1854-0094
Q25	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
Q26	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223

Table 7-14. FM Record/Reproduce PCA, Parts List (Continued)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
Q27	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q28	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q29	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q30	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q31	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q32	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q33	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q34	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q35	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q36	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q37	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q38	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q39	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q40	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q41	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q42	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q43	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q44	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q45	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0223
Q46	1854-0210	2	TRANSISTOR NPN 2N2222 SI TO-18 PD=500MW	04713	2N2222
Q47	1854-0210		TRANSISTOR NPN 2N2222 SI TO-18 PD=500MW	04713	2N2222
R1	2100-3467	1	RESISTOR-VAR W/SW 100K 10% LIN	28480	2100-3467
R2	0757-0438	5	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
R3	0757-0436	5	RESISTOR 4.32K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4321-F
R4	0757-0443	1	RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1102-F
R5	0698-7634	1	RESISTOR 42.2K 1% .125W F TC=0+-25	19701	MF4C1/8-T9-4222-F
R6	0698-3550	1	RESISTOR 127K 1% .125W F TC=0+-25	24546	NE55
R7	0698-7652	1	RESISTOR 49.9K 1% .125W F TC=0+-25	19701	MF4C1/8-T9-4992-F
R8	0757-0280	4	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
R9	2100-3103	3	RESISTOR-TRMR 10K 10% C SIDE-ADJ 17-TRN	32997	3006P-1-103
R10	0698-6481	1	RESISTOR 16.2K 1% .125W F TC=0+-25	24546	NE55
R11	0698-8639	2	RESISTOR 2.94K 1% .125W F TC=0+-25	24546	NE55
R12	2100-3103		RESISTOR-TRMR 10K 10% C SIDE-ADJ 17-TRN	32997	3006P-1-103
R13	0698-8780	2		28480	0698-8780
R14	0698-3446	2	RESISTOR 383 1% .125W F TC=0+-100	24546	C4-1/8-T0-383R-F
R15	0698-8773	2	RESISTOR 237 1% .125W F TC=0+-25	19701	MF4C-1
R16	0757-0123	2	RESISTOR 34.8K 1% .125W F TC=0+-100	24546	C4, T-0
R17	0757-0279	3	RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
R18	0698-8774	4	RESISTOR 562 1% .125W F TC=0+-25	19701	MF4C-1
R19	0698-8774		RESISTOR 562 1% .125W F TC=0+-25	19701	MF4C-1
R20	0757-0422	2	RESISTOR 909 1% .125W F TC=0+-100	24546	C4-1/8-T0-909R-F
R21	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
R22	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
R23	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
R24	0757-0420	1	RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
R25	0757-0444	2	RESISTOR 12.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1212-F
R26	0757-0444		RESISTOR 12.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1212-F
R27	0757-0398	2	RESISTOR 75 1% .125W F TC=0+-100	24546	C4-1/8-T0-75R0-F
R28	0757-0398		RESISTOR 75 1% .125W F TC=0+-100	24546	C4-1/8-T0-75R0-F
R29	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
R30	0698-3445	1	RESISTOR 348 1% .125W F TC=0+-100	24546	C4-1/8-T0-348R-F
R31*	0698-3447	1	RESISTOR 422 1% .125W F TC=0+-100	24546	C4-1/8-T0-422R-F
R33	0757-0440	1	RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
R34	2100-3273	1	RESISTOR-TRMR 2K 10% C SIDE-ADJ 1-TRN	73138	72-144-0
R35	0757-0316	1	RESISTOR 42.2 1% .125W F TC=0+-100	24546	C4-1/8-T0-42R2-F
R36	0757-0346	1	RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
R37	0757-0283	1	RESISTOR 2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2001-F
R38	2100-3207	1	RESISTOR-TRMR 5K 10% C SIDE-ADJ 1-TRN	73138	72-145-0
R39	0698-3151	1	RESISTOR 2.87K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2871-F
R40	0757-0446	3	RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R41	0698-3455	1	RESISTOR 261K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2613-F
R42	0757-0464	1	RESISTOR 90.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-9092-F
R43	0757-0274	1	RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1213-F
R44	0698-0082	1	RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
R45	0757-0467	1	RESISTOR 121K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1213-F
R46	0757-0279		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
R47	0757-0442	1	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
R48	0757-0273	1	RESISTOR 3.01K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3011-F
R49	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
R50	0698-3154	3	RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
R51	0698-3154		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
R52	0698-3158	1	RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2372-F
R53	0698-3159	1	RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F
R54	0698-4527	1	RESISTOR 205K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2053-F
R55	0757-0199	5	RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
R56	0698-8639		RESISTOR 2.94K 1% .125W F TC=0+-25	24546	NE55

Table 7-14. FM Record/Reproduce PCA, Parts List (Continued)

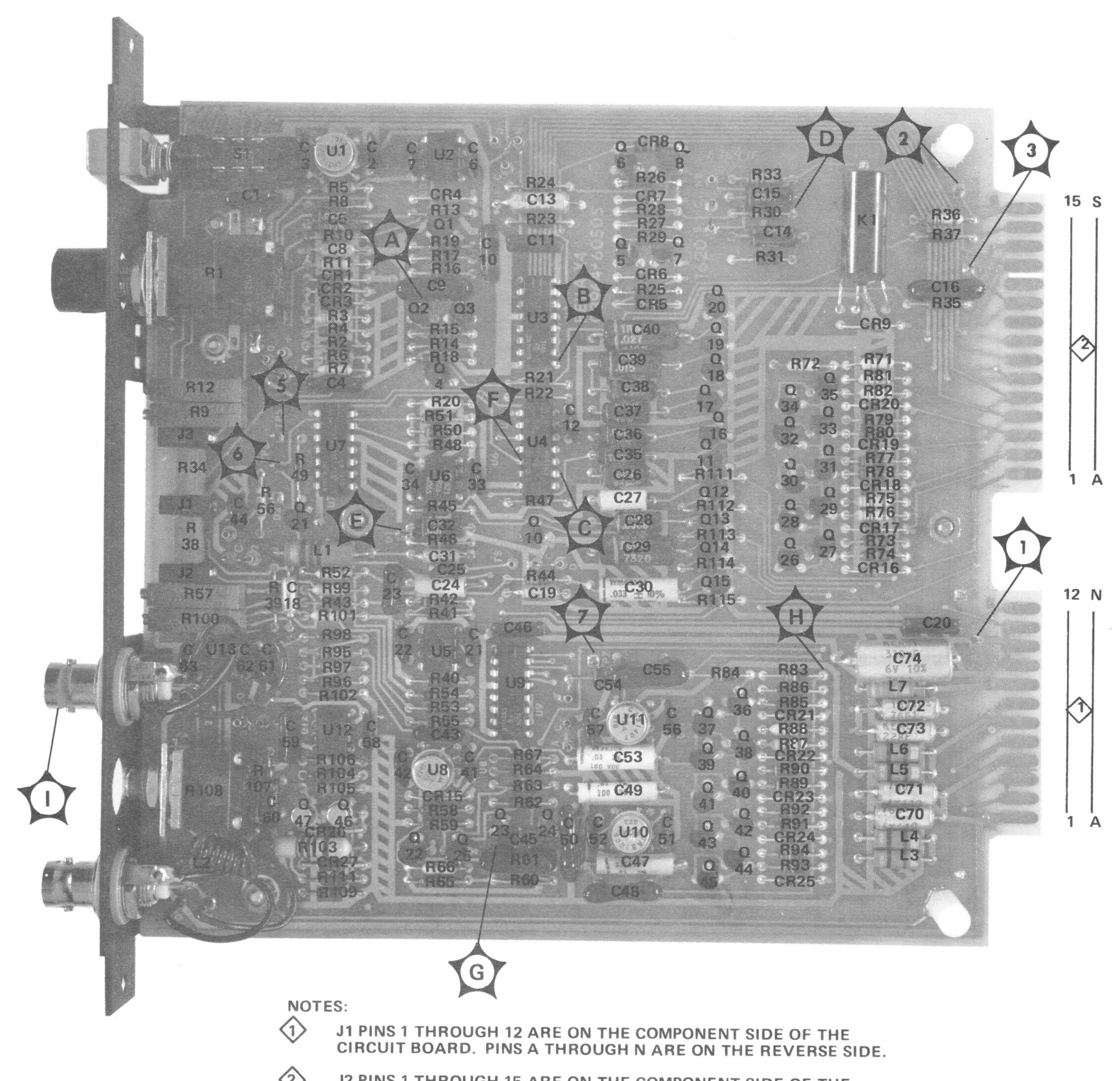
Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
R57	2100-3103		RESISTOR-TRMR 10K 10% C SIDE-ADJ 17-TRN	32997	3006P-1-103
R58	0698-8804	1	RESISTOR–27.4K 1% .125W	28480	0698-8804
R59	0698-8803	1	RESISTOR– 5.9K 1% .125W	28480	0698-8803
R60	0698-3446		RESISTOR 383 1% .125W F TC=0+-100	24546	C4-1/8-T0-383R-F
R61	0698-8773		RESISTOR 237 1% .125W F TC=0+-25	19701	MF4C-1
R62	0757-0123		RESISTOR 34.8K 1% .125W F TC=0+-100	24546	C4, T-0
R63	0757-0279		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
R64	0698-8774		RESISTOR 562 1% .125W F TC=0+-25	19701	MF4C-1
R65	0698-8774		RESISTOR 562 1% .125W F TC=0+-25	19701	MF4C-1
R66	0757-0422		RESISTOR 909 1% .125W F TC=0+-100	24546	C4-1/8-T0-909R-F
R67	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
R71	0757-0460	4	RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
R72	0757-0460		RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
R73	0698-4433	2	RESISTOR 2.26K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2261-F
R74	0698-4433		RESISTOR 2.26K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2261-F
R75	0757-0436		RESISTOR 4.32K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4321-F
R76	0757-0436		RESISTOR 4.32K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4321-F
R77	0698-4202	2	RESISTOR 8.87K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8871-F
R78	0698-4202		RESISTOR 8.87K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8871-F
R79	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
R80	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
R81	0757-0460		RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
R82	0757-0460		RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
R83	0698-4502	4	RESISTOR 64.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6492-F
R84	0698-4502		RESISTOR 64.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6492-F
R85	0698-4432	2	RESISTOR 2.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2101-F
R86	0698-4432		RESISTOR 2.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2101-F
R87	0757-0436		RESISTOR 4.32K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4321-F
R88	0757-0436		RESISTOR 4.32K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4321-F
R89	0698-0064	2	RESISTOR 9.31K 1% .125W F TC=0+-100	91637	CMF-1/8-T1-9311-F
R90	0698-0064		RESISTOR 9.31K 1% .125W F TC=0+-100	91637	CMF-1/8-T1-9311-F
R91	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
R92	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
R93	0698-4502		RESISTOR 64.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6492-F
R94	0698-4502		RESISTOR 64.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6492-F
R95	0698-5542	1	RESISTOR 20K 1% .125W F TC=0+-25	24546	NE55
R96	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R97	0698-8645	1	RESISTOR 348K 1% .125W F TC=0+-25	24546	NE55
R98	0698-7082	1	RESISTOR 100K 1% .125W F TC=0+-25	24546	NE55
R99	0698-6587	2	RESISTOR 37.4K 1% .125W F TC=0+-25	24546	NE55
R100	2100-3056	1	RESISTOR-TRMR 5K 10% C 17-TRN	28480	2100-3056
R101	0698-6587		RESISTOR 37.4K 1% .125W F TC=0+-25	24546	NE55
R102	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
R103	0757-0798	1	RESISTOR 110 1% .5W F TC=0+-100	19701	MF7C-1/2-T0-111-F
R104	0698-3154		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
R105	0757-0290	1	RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
R106	0698-3440	1	RESISTOR 196 1% .125W F TC=0+-100	24546	C4-1/8-T0-196R-F
R107	0757-0446		RESISTOR 15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1502-F
R108	2100-3468	1	RESISTOR-VAR CONTROL CC 2K 10% LIN	01121	70A1G024B202U
R109	0698-3444	1	RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F
R110	0757-0394	1	RESISTOR 51.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-51R1-F
R111	0698-3161	2	RESISTOR 38.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3832-F
R115	0698-3161		RESISTOR 38.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3832-F
S1	3101-2099	1	SWITCH-PB DPDT ALTNG .5A 100VAC	28480	3101-2099
	03968-20002	1	BUTTON, ENGRAVED FM	28480	03968-20002
U1	1826-0406	3	IC LINEAR	28480	1826-0406
U2	1820-0493	1	IC LM 307 OP AMP	27014	LM307N
U3	1820-0744	2	IC-DIGITAL SN7497N TTL BIN SYNCHRO	01295	SN7497N
U4	1820-0077	1	IC-DIGITAL SN7474N TTL DUAL D-TYPE	01295	SN7474N
U5	1826-0207	1	IC LM 318 OP AMP	27014	LM318N
U6	1826-0065	1	IC LM 311 COMPARATOR	27014	LM311N
U7	1820-1211	1	IC-DIGITAL SN74LS86N TTL LS QUAD 2	01295	SN74LS86N
U8	1826-0243	1	IC MC 1558 OP AMP	27014	LM1558H
U9	1820-0744		IC-DIGITAL SN7497N TTL BIN SYNCHRO	01295	SN7497N
U10	1826-0407	2	IC LINEAR	28480	1826-0407
U11	1826-0407		IC LINEAR	28480	1826-0407
U12	1826-0296		IC CA 207 OP AMP	02735	CA207E
U13	1826-0296		IC CA 207 OP AMP	02735	CA207E
			MISCELLANEOUS		
	0360-0124	2	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-0124
	0360-1190	2	TERMINAL-LUG-SLDR 3/8 SCR .38/.078 ID	79963	720-.380H
	0360-1514	15	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
	0362-0227	2	TERMINAL-CRIMP QDISC-FEM 30-24-AWG	28480	0362-0227
	0370-0473	1	KNOB:ROUND	28480	0370-0473

Table 7-14. FM Record/Reproduce PCA, Parts List (Continued)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	0470-0039		ADHESIVE KIT(EPOXY, 2-PART)	04347	0151
	1251-2176	23	CONNECTOR-SGL CONT SKT .025-DIA TFE	71279	3394-2-03
	1250-0118	2	CONNECTOR-RF BNC FEM SGL-HOLE-FR 50-OHM	24931	28JR128-1
	1460-1409	7	WIREFORM .2-W .42-LG	28480	1460-1409
	2190-0163	2	WASHER-LK INTL T NO.-3/8 .38-IN-ID	78189	1220-05
	2260-0009	6	NUT-HEX-W/LKWR 4-40-THD .094-THK .25-A/F	28480	2260-0011
	2950-0001	2	NUT-HEX-DBL-CHAM 3/8-32-THD .094-THK	28480	2950-0030
	8150-0301		WIRE 24AWG R 1000V PVC 7X32 105C	28480	8150-0301
	8150-0302		WIRE 24AWG BR 1000V PVC 7X32 105C	28480	8150-0302
	8150-0303		WIRE 24AWG BK 1000V PVC 7X32 105C	28480	8150-0303
	5040-0702	4	INSULATOR:CONNECTOR	28480	5040-0702
	03964-00205	1	FM DATA SHIELD MARKER	28480	03964-00205
	03968-00530	2	MOUNT, POT	28480	03968-00530
	03968-20070	2	GUIDE, BOARD	28480	03968-20070
	03968-20481	6	SPACER, 102	28480	03968-20481

NOTE

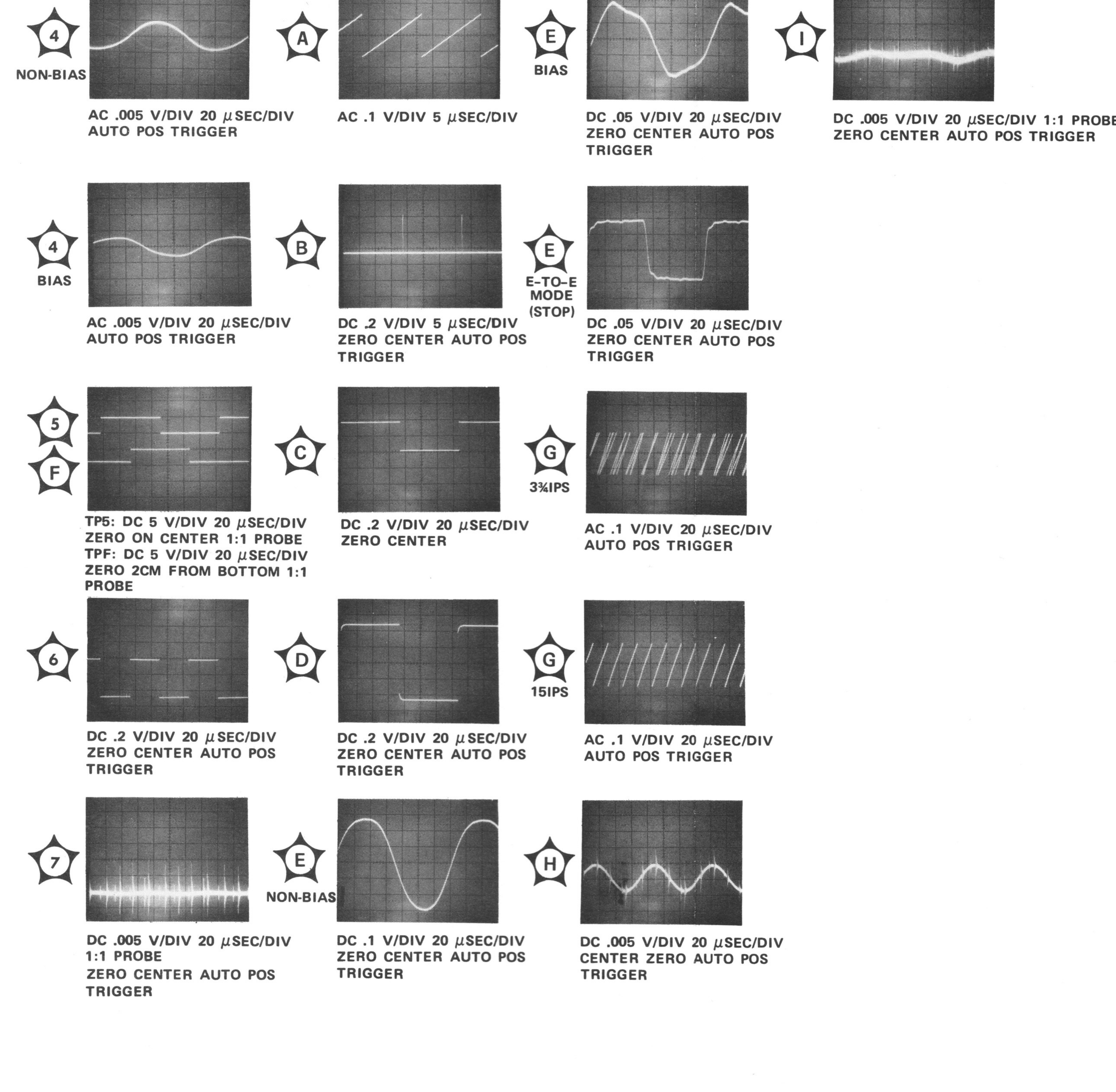
*ON MODEL 3964A RECORDERS, WITH SERIAL NUMBERS 493 AND ABOVE, WHICH HAVE INFOMAG RECORD HEADS (ITEM 71, FIGURE 6-2) CHANGE THE VALUE OF R31 TO 316 OHM, PART NO. 0698-3444.



NOTES:

1. J1 PINS 1 THROUGH 12 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH N ARE ON THE REVERSE SIDE.
2. J2 PINS 1 THROUGH 15 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH N ARE ON THE REVERSE SIDE.

Figure 7-39. FM Record/Reproduce PCA, Parts Location



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SERVICE SHEET

Figure 7-40. FM Record/Reproduce PCA (Option 001), Schematic Diagram

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SERVICE SHEET

Figure 7-41. Direct Record/Reproduce Circuits (Option 002), Servicing Diagram

Table 7-15. Direct Record/Reproduce PCA A11—A18, Parts List

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A11-A14	03964-60510	4	PCA, DIRECT RECORD/REPRODUCE	28480	03964-60510
A11-A18	03964-60510		PCA, DIRECT RECORD/REPRODUCE	28480	03964-60510
A11-A18	03968-60510	8	PCA, DIRECT RECORD/REPRODUCE (3968A)	28480	03968-60510
C201	0160-0174	1	CAPACITOR-FXD .47UF +80-20% 25VDC CER	28480	0160-0174
C202	0180-1747	4	CAPACITOR-FXD 150UF+-20% 15VDC TA	0420J	150D157X0015
C203	0180-1747		CAPACITOR-FXD 150UF+-20% 15VDC TA	0420J	150D157X0015
C204	0140-0197	1	CAPACITOR-FXD 180PF +-5% 300VDC MICA0+70	72136	DM15F181J0300WV1CR
C205	0160-2055	12	CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
C206	0160-2243	2	CAPACITOR-FXD 2.7PF +-.25PF 500VDC	28480	0160-2243
C207	0160-2055		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
C208	0180-1747		CAPACITOR-FXD 150UF+-20% 15VDC TA	0420J	150D157X0015
C209	0180-1747		CAPACITOR-FXD 150UF+-20% 15VDC TA	0420J	150D157X0015
C210	0180-0228	2	CAPACITOR-FXD 22UF+-10% 15VDC TA	0420J	150D226X9015B2
C211	0180-0228		CAPACITOR-FXD 22UF+-10% 15VDC TA	0420J	150D226X9015B2
C212	0160-2223	1	CAPACITOR-FXD 1600PF +-5% 300VDC	28480	0160-2223
C213	0160-0362	3	CAPACITOR-FXD 510PF +-5% 300VDC MICA0+70	28480	0160-0362
C214	0160-3539	1	CAPACITOR-FXD 820PF +-5% 100VDC MICA0+70	28480	0160-3539
C215	0160-4338	2	CAPACITOR-FXD .082UF +-5% 100VDC POLYSTY	84411	863T
C216	0160-4338		CAPACITOR-FXD .082UF +-5% 100VDC POLYSTY	84411	863T
C217	0160-2055		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
C218	0160-2236	2	CAPACITOR-FXD 1PF +-.25PF 500VDC	28480	0160-2236
C219	0160-2055		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
C220	0150-0121	6	CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0150-0121
C221	0150-0121		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0150-0121
C222	0150-0121		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0150-0121
C223	0150-0121		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0150-0121
C224	0150-0121		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0150-0121
C225	0150-0121		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0150-0121
C226	0160-0937	2	CAPACITOR-FXD 1000PF +-2% 300VDC	28480	0160-0937
C227	0160-0937		CAPACITOR-FXD 1000PF +-2% 300VDC	28480	0160-0937
C228	0160-2055		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
C229	0160-2204	1	CAPACITOR-FXD 100PF +-5% 300VDC MICA0+70	28480	0160-2204
C230	0160-2055		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
C231	0160-3122	2	CAPACITOR-FXD 1UF +-10% 50VDC POLYC	84411	463UW1059R5W2
C232	0160-0362		CAPACITOR-FXD 510PF +-5% 300VDC MICA0+70	28480	0160-0362
C233	0160-2222	1	CAPACITOR-FXD 1500PF +-5% 300VDC	28480	0160-2222
C234	0160-2031	1	CAPACITOR-FXD 3600PF +-5% 500VDC	28480	0160-2031
C235	0140-0170	2	CAPACITOR-FXD 5600PF +-5% 300VDC MICA	72136	DM20F562J0300WV1CR
C236	0160-2225	4	CAPACITOR-FXD 2000PF +-5% 300VDC	28480	0160-2225
C237	0160-2735	1	CAPACITOR-FXD 1000PF +-5% 100VDC	28480	0160-2735
C238	0160-3704	1	CAPACITOR-FXD .015UF +-5% 50VDC	28480	0160-3704
C239	0160-0362		CAPACITOR-FXD 510PF +-5% 300VDC MICA0+70	28480	0160-0362
C240	0160-2055		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
C241	0160-2243		CAPACITOR-FXD 2.7PF +-.25PF 500VDC	28480	0160-2243
C242	0160-2055		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
C243	0160-0183	2	CAPACITOR-FXD 130PF +-5% 300VDC MICA0+70	28480	0160-0183
C244	0160-0958	1	CAPACITOR-FXD 390PF +-5% 300VDC MICA0+70	28480	0160-0958
C245	0160-0945	1	CAPACITOR-FXD 910PF +-5% 100VDC MICA0+70	28480	0160-0945
C246	0160-2225		CAPACITOR-FXD 2000PF +-5% 300VDC	28480	0160-2225
C247	0160-2225		CAPACITOR-FXD 2000PF +-5% 300VDC	28480	0160-2225
C248	0160-2225		CAPACITOR-FXD 2000PF +-5% 300VDC	28480	0160-2225
C249	0160-0183		CAPACITOR-FXD 130PF +-5% 300VDC MICA0+70	28480	0160-0183
C250	0160-2055		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
C251	0160-2236		CAPACITOR-FXD 1PF +-.25PF 500VDC	28480	0160-2236
C252	0160-2055		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
C253	0160-2432	1	CAPACITOR-FXD .1UF +-5% 100VDC POLYSTY	84411	863T10451W2
C254	0160-2226	1	CAPACITOR-FXD 2200PF +-5% 300VDC	28480	0160-2226
C255	0160-2208	1	CAPACITOR-FXD 330PF +-5% 300VDC MICA0+70	28480	0160-2208
C256	0140-0170		CAPACITOR-FXD 5600PF +-5% 300VDC MICA	72136	DM20F562J0300WV1CR
C257	0160-3122		CAPACITOR-FXD 1UF +-10% 50VDC POLYC	84411	463UW1059R5W2
C258	0160-2055		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
C259	0160-4339	1	CAPACITOR-FXD .018UF +-5% 100VDC POLYSTY	84411	863T
C260	0160-2055		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
CR201	1901-0044	5	DIODE-SWITCHING 50V 50MA 6NS	28480	1901-0044
CR202	1901-0044		DIODE-SWITCHING 50V 50MA 6NS	28480	1901-0044
CR203	1901-0025	1	DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
CR204	1901-0044		DIODE-SWITCHING 50V 50MA 6NS	28480	1901-0044
CR205	1902-0049	4	DIODE-ZNR 6.19V 5% DO-7 PD=.4W TC=+.022%	0223G	FZ7240
CR206	1901-0044		DIODE-SWITCHING 50V 50MA 6NS	28480	1901-0044
CR207	1902-0049		DIODE-ZNR 6.19V 5% DO-7 PD=.4W TC=+.022%	0223G	FZ7240
CR208	1902-0049		DIODE-ZNR 6.19V 5% DO-7 PD=.4W TC=+.022%	0223G	FZ7240
CR209	1902-0049		DIODE-ZNR 6.19V 5% DO-7 PD=.4W TC=+.022%	0223G	FZ7240
CR210	1901-0044		DIODE-SWITCHING 50V 50MA 6NS	28480	1901-0044

Table 7-15. Direct Record/Reproduce PCA A11–A18, Parts List (Continued)

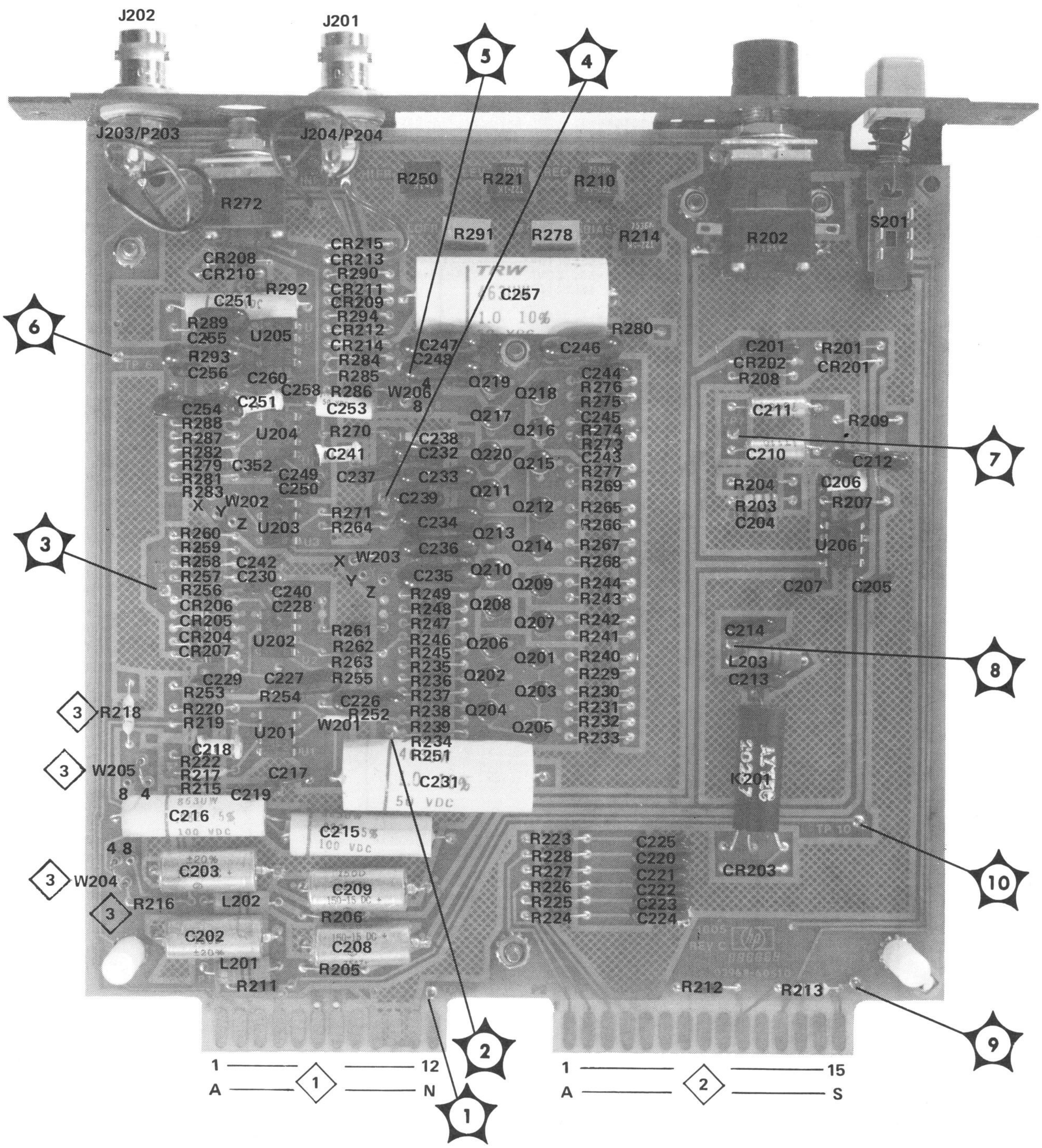
Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
CR211	1902-0044	1	DIODE-ZNR 18V 1% DO-14	28480	1902-0044
CR212	1901-0050	2	DIODE-SWITCHING 80V 200MA 2NS DO-7	28480	1901-0050
CR213	1901-0050		DIODE-SWITCHING 80V 200MA 2NS DO-7	28480	1901-0050
CR214	1902-0551	2	DIODE-ZNR 6.19V 5% DO-15 PD=1W TC=+.022%	28480	1902-0551
CR215	1902-0551		DIODE-ZNR 6.19V 5% DO-15 PD=1W TC=+.022%	28480	1902-0551
J201	1250-0118	2	CONNECTOR-RF BNC FEM SGL-HOLE-FR 50-OHM	0331F	28JR128-1
J202	1250-0118		CONNECTOR-RF BNC FEM SGL-HOLE-FR 50-OHM	0331F	28JR128-1
J203	0360-1514	14	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
J204	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
K201	0490-0326	1	RELAY-REED 1A 500MA 250VAC 24VDC-COIL	0369E	101-100-24
L201	9100-1649	3	COIL-MLD 620UH 5% Q=60 .19DX.44LG	0217B	19-1331-30J
L202	9100-1649		COIL-MLD 620UH 5% Q=60 .19DX.44LG	0217B	19-1331-30J
L203	9100-1649		COIL-MLD 620UH 5% Q=60 .19DX.44LG	0217B	19-1331-30J
P203	0362-0227	4	CONNECTOR-SGL CONT SKT 1.14-MM-BSC-SZ	28480	0362-0227
P204	0362-0227		CONNECTOR-SGL CONT SKT 1.14-MM-BSC-SZ	28480	0362-0227
Q201	1855-0223	20	TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q202	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q203	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q204	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q205	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q206	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q207	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q208	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q209	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q210	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q211	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q212	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q213	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q214	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q215	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q216	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q217	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q218	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q219	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
Q220	1855-0223		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	28480	1855-0223
R201	0757-0438	1	RESISTOR 5.11K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-5111-F
R202	2100-3467	1	RESISTOR-VAR W/SW 100K 10% LIN	28480	2100-3467
R203	0757-0290	2	RESISTOR 6.19K 1% .125W F TC=0+-100	0299E	MF4C1/8-T0-6191-F
R204	0757-0439	1	RESISTOR 6.81K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-6811-F
R205	0757-0401	7	RESISTOR 100 1% .125W F TC=0+-100	0329B	C4-1/8-T0-101-F
R206	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	0329B	C4-1/8-T0-101-F
R207	0757-0465	4	RESISTOR 100K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-1003-F
R208	0698-4429	1	RESISTOR 1.87K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-1871-F
R209	0757-0424	1	RESISTOR 1.1K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-1101-F
R210	2100-2522	1	RESISTOR-TRMR 10K 10% C SIDE-ADJ 1-TRN	0365A	ET50X103
R211	0757-0280	13	RESISTOR 1K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-1001-F
R212	0698-3442	1	RESISTOR 237 1% .125W F TC=0+-100	0329B	C4-1/8-T0-237R-F
R213	0757-0346	1	RESISTOR 10 1% .125W F TC=0+-100	0329B	C4-1/8-T0-10R0-F
R214	2100-2489	1	RESISTOR-TRMR 5K 10% C SIDE-ADJ 1-TRN	0365A	ET50X502
R215	0698-4444	2	RESISTOR 4.87K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-4871-F
R216	0698-4444		RESISTOR 4.87K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-4871-F
R217	0698-4508	3	RESISTOR 78.7K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-7872-F
R218	0698-4508		RESISTOR 78.7K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-7872-F
R219	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-1003-F
R220	0757-0283	1	RESISTOR 2K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-2001-F
R221	2100-2413	1	RESISTOR-TRMR 200 10% C SIDE-ADJ 1-TRN	0365A	ET50X201
R222	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	0329B	C4-1/8-T0-101-F
R223	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-1001-F
R224	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-1001-F
R225	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-1001-F
R226	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-1001-F
R227	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-1001-F
R228	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-1001-F
R229	0698-7187	20	RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R230	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R231	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R232	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R233	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R234	0698-4505	3	RESISTOR 71.5K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-7152-F
R235	0698-8644	2	RESISTOR 2.273K .1% .125W F TC=0+-25	0329B	NE55
R236	0698-8640	2	RESISTOR 4.734K .1% .125W F TC=0+-25	0329B	NE55
R237	0698-4476	2	RESISTOR 10.2K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-1022-F
R238	0698-3158	3	RESISTOR 23.7K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-2372-F
R239	0698-4505		RESISTOR 71.5K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-7152-F
R240	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055

Table 7-15. Direct Record/Reproduce PCA A11—A18, Parts List (Continued)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
R241	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R242	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R243	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R244	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R245	0698-8644		RESISTOR 2.273K .1% .125W F TC=0+-25	03298	NE55
R246	0698-8640		RESISTOR 4.734K .1% .125W F TC=0+-25	03298	NE55
R247	0698-4476		RESISTOR 10.2K 1% .125W F TC=0+-100	03298	C4-1/8-T0-1022-F
R248	0698-3158		RESISTOR 23.7K 1% .125W F TC=0+-100	03298	C4-1/8-T0-2372-F
R249	0698-4505		RESISTOR 71.5K 1% .125W F TC=0+-100	03298	C4-1/8-T0-7152-F
R250	2100-2633	1	RESISTOR-TRMR 1K 10% C SIDE-ADJ 1-TRN	0365A	ET50X102
R251	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	03298	C4-1/8-T0-101-F
R252	0698-3441	1	RESISTOR 215 1% .125W F TC=0+-100	03298	C4-1/8-T0-215R-F
R253	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	03298	C4-1/8-T0-1001-F
R254	0698-3443	1	RESISTOR 287 1% .125W F TC=0+-100	03298	C4-1/8-T0-287R-F
R255	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	03298	C4-1/8-T0-1001-F
R256	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	03298	C4-1/8-T0-101-F
R257	0757-0416	1	RESISTOR 511 1% .125W F TC=0+-100	03298	C4-1/8-T0-511R-F
R258	0757-0447	1	RESISTOR 16.2K 1% .125W F TC=0+-100	03298	C4-1/8-T0-1622-F
R259	0757-0449	1	RESISTOR 20K 1% .125W F TC=0+-100	03298	C4-1/8-T0-2002-F
R260	0757-0123	1	RESISTOR 34.8K 1% .125W F TC=0+-100	0160G	CC
R261	0757-0199	2	RESISTOR 21.5K 1% .125W F TC=0+-100	03298	C4-1/8-T0-2152-F
R262	0698-3158		RESISTOR 23.7K 1% .125W F TC=0+-100	03298	C4-1/8-T0-2372-F
R263	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	03298	C4-1/8-T0-2152-F
R264	0757-0290		RESISTOR 6.19K 1% .125W F TC=0+-100	0299E	MF4C1/8-T0-6191-F
R265	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R266	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R267	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R268	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R269	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R270	0698-3160	1	RESISTOR 31.6K 1% .125W F TC=0+-100	03298	C4-1/8-T0-3162-F
R271	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	03298	C4-1/8-T0-101-F
R272	2100-3468	1	RESISTOR-VAR CONTROL CC 2K 10% LIN	0160G	70A1G0248202U
R273	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R274	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R275	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R276	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R277	0698-7187		RESISTOR 2M 5% .125W CC TC=-666/+1262	0160G	BB2055
R278	2100-3355	1	RESISTOR-TRMR 100K 10% C SIDE-ADJ 1-TRN	73138	72-150-0
R279	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	03298	C4-1/8-T0-1003-F
R280	0698-3159	1	RESISTOR 26.1K 1% .125W F TC=0+-100	03298	C4-1/8-T0-2612-F
R281	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	03298	C4-1/8-T0-1003-F
R282	0698-0083	1	RESISTOR 1.96K 1% .125W F TC=0+-100	03298	C4-1/8-T0-1961-F
R283	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	03298	C4-1/8-T0-1001-F
R284	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	03298	C4-1/8-T0-101-F
R285	0698-3259	1	RESISTOR 7.87K 1% .125W F TC=0+-100	03298	C4-1/8-T0-7871-F
R286	0698-4508		RESISTOR 78.7K 1% .125W F TC=0+-100	03298	C4-1/8-T0-7872-F
R287	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	03298	C4-1/8-T0-1001-F
R288	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	03298	C4-1/8-T0-1001-F
R289	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	03298	C4-1/8-T0-1001-F
R290	0757-0442	1	RESISTOR 10K 1% .125W F TC=0+-100	03298	C4-1/8-T0-1002-F
R291	2100-2517	1	RESISTOR-TRMR 50K 10% C SIDE-ADJ 1-TRN	0365A	ET50X503
R292	0698-3456	1	RESISTOR 287K 1% .125W F TC=0+-100	03298	C4-1/8-T0-2873-F
R293	0757-0394	2	RESISTOR 51.1 1% .125W F TC=0+-100	03298	C4-1/8-T0-51R1-F
R294	0757-0394		RESISTOR 51.1 1% .125W F TC=0+-100	03298	C4-1/8-T0-51R1-F
S201	3101-1658	1	SWITCH-PB DPDT ALTNG 1A 300VAC	31918	F-2U-EE
	03968-20003		S201 BUTTON, ENGRAVED D	28480	03968-20003
TP1	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
TP2	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
TP3	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
TP4	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
TP5	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
TP6	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
TP7	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
TP8	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
TP9	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
TP10	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
U201	1826-0207	6	IC OP AMP	0340F	LM318N
U202	1826-0207		IC OP AMP	0340F	LM318N
U203	1826-0207		IC OP AMP	0340F	LM318N
U204	1826-0207		IC OP AMP	0340F	LM318N
U205	1826-0207		IC OP AMP	0340F	LM318N
U206	1826-0207		IC OP AMP	0340F	LM318N
W201	1460-1409	5	WIREFORM	28480	1460-1409
W202	1460-1409		WIREFORM	28480	1460-1409
W203	1460-1409		WIREFORM	28480	1460-1409
W204	1460-1409		WIREFORM (3964A ONLY)	28480	1460-1409

Table 7-15. Direct Record/Reproduce PCA A11–A18, Parts List (Continued)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
W205	1460-1409		WIREFORM (3964A ONLY)	28480	1460-1409
XW201	1251-2176	6	CONNECTOR-SGL CONT SKT .025-IN-BSC-SZ (2;STRAP)	0447E	3394-2-03
XW202	1251-2176		CONNECTOR-SGL CONT SKT .025-IN-BSC-SZ (3;XYZ SELECTOR)	0447E	3394-2-03
XW203	1251-2176		CONNECTOR-SGL CONT SKT .025-IN-BSC-SZ (3;XYZ SELECTOR)	0447E	3394-2-03
XW204	1251-2176		CONNECTOR-SGL CONT SKT .025-IN-BSC-SZ (3;R216 SELECTOR)	0447E	3394-2-03
XW205	1251-2176		CONNECTOR-SGL CONT SKT .025-IN-BSC-SZ (3;R218 SELECTOR)	0447E	3394-2-03
XW206	1251-2176		CONNECTOR-SGL CONT SKT .025-IN-BSC-SZ (3;R286 SELECTOR)	0447E	3394-2-03
			A11-A18 DIRECT PCA MISCELLANEOUS		
	0360-1190	16	TERMINAL-SLDR LUG PL-MTG FOR-#3/8-SCR	79963	720-.380H
	0370-0473	8	KNOB;ROUND	28480	0370-0473
	0380-0917	48	SPACER-RND .125LG .115ID .250D FBR	0217J	9222
	2190-0163	16	WASHER-LK INTL T 3/8 IN .38-IN-ID	78189	1220-05
	2260-0009	56	NUT-HEX-W/LKWR 4-40-THD .094-IN-THK	28480	2260-0009
	2950-0001	16	NUT-HEX-DBL-CHAM 3/8-32-THD .094-IN-THK	28480	2950-0001
	8150-0301		WIRE 24AWG R 300V PVC 7X32 80C	28480	8150-0301
	8150-0303		WIRE 24AWG BK 300V PVC 7X32 80C	28480	8150-0303
	5040-0702	32	INSULATOR;CONNECTOR	28480	5040-0702
	03960-00740	8	INSERT, DIRECT RECORD	28480	03960-00740
	03968-00202	8	SHIELD, DATA MARKER	28480	03968-00202
	03968-00530	16	MOUNT, POT	28480	03968-00530
	03968-20070	16	GUIDE, BOARD	28480	03968-20070
	03968-20481	6	SPACER, 102	28480	03968-20481
	0540-0702	4	WASHER	28480	0540-0702
	2950-0043	2	NUT-HEX-DBL-CHAM 3/8-32-THD .094-IN-THK	28480	2950-0043



NOTES:

1. J1 PINS 1 THROUGH 12 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH N ARE ON THE REVERSE SIDE.

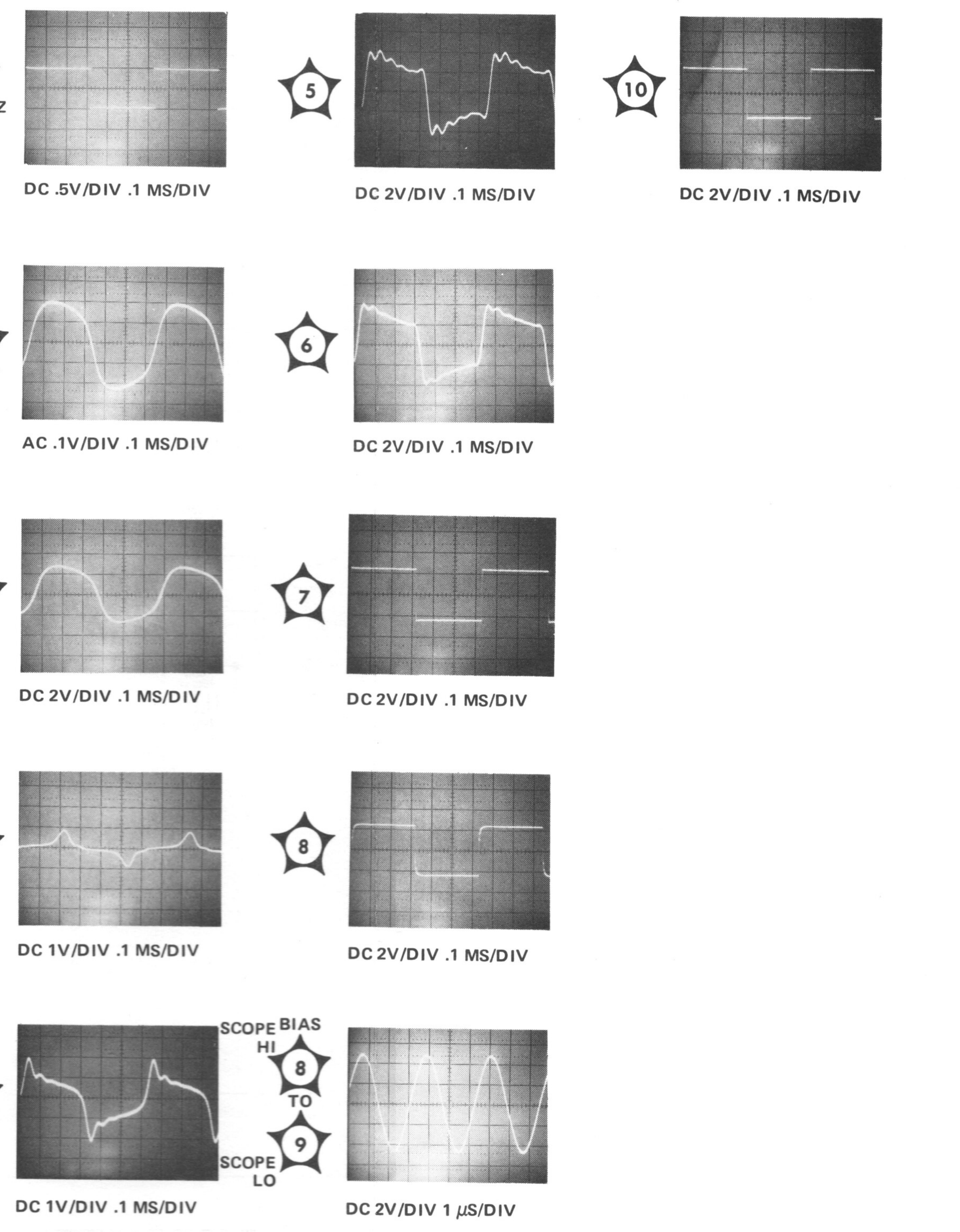
2. J2 PINS 1 THROUGH 15 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH S ARE ON THE REVERSE SIDE.

3. 3964A ONLY

Figure 7-42. Direct Record/Reproduce PCA (Option 002), Parts Location

NOTES:

1. CHAN 8 INPUT IN THE 3968 AND THE CHAN 4 INPUT IN THE 3964 ARE ROUTED THROUGH THE VOICE CIRCUIT (SEE SERVICE SHEET 19)
2. 3968 PART NO.– 03968-60510
   3964 PART NO.– 03964-60510
3. JUMPERS W204, W205, W206 AND RESISTORS R216,218,281 INSTALLED ON 03964-60510 (3964) ONLY



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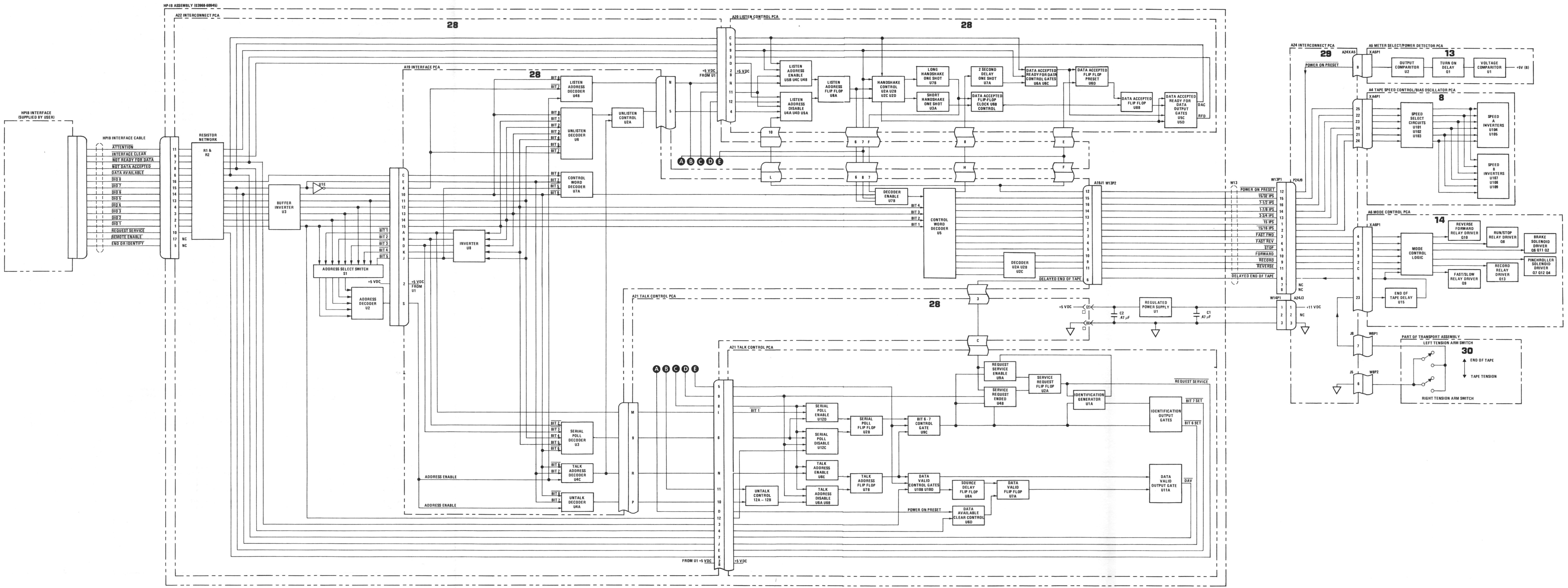
SERVICE SHEET

Figure 7-43. Direct Record/Reproduce Circuit (Option 002), Schematic Diagram



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SERVICE SHEET

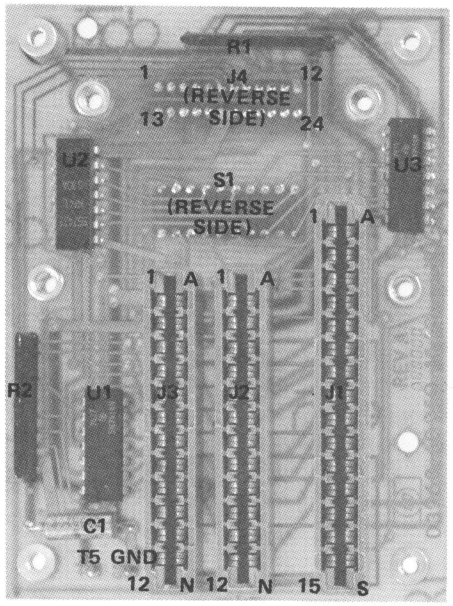
Figure 7-44. HP-IB Interface Circuits (Option 007), Servicing Diagram

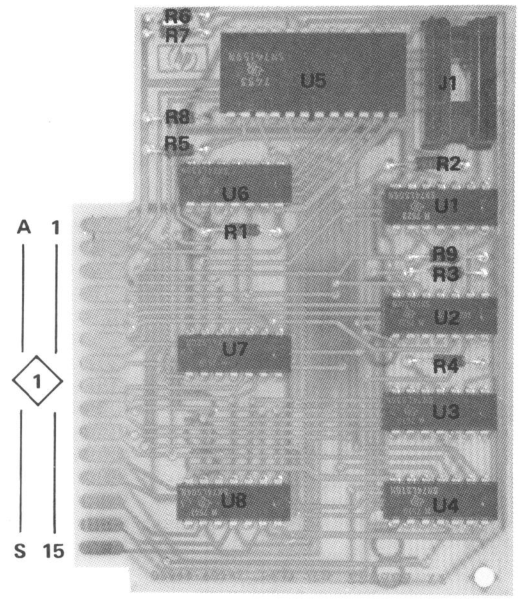
Table 7-16. HP-IB Assemblies A19—A22, Parts List (Option 007)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A19	03968-60947	1	HP-IB INTERFACE, PCA	28480	03968-60947
A19R1	0757-0280	2	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A19R2	0757-0442	7	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A19R3	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A19R4	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A19R5	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A19R6	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A19R7	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A19R8	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A19R9	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A19U1	1820-1200	1	IC SN74LS 05 N INV	01295	SN74LS05N
A19U2	1820-1197	1	IC SN74LS 00 N GATE	01295	SN74LS00N
A19U3	1820-1207	2	IC SN74LS 30 N GATE	01295	SN74LS30N
A19U4	1820-1202	1	IC SN74LS 10 N GATE	01295	SN74LS10N
A19U5	1820-1257	1	IC SN74 159 N DECODER	01295	SN74159
A19U6	1820-1207		IC SN74LS 30 N GATE	01295	SN74LS30N
A19U7	1820-1204	1	IC SN74LS 20 N GATE	01295	SN74LS20N
A19U8	1820-1199	1	IC SN74LS 04 N INV	01295	SN74LS04N
	1200-0767	1	SOCKET-IC 16-CONT DIP-SLDR-TERMS	91506	316-AG50-3R
A20	03968-60948	1	HP-IB LISTEN CONTROL, PCA	28480	03968-60948
A20C1	0160-0174	1	CAPACITOR-FXD .47UF +80-20% 25WVDC CER	56289	5C11B7-CML
A20C2	0160-0153	1	CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE	56289	292P10292
A20C3	0180-0116	1	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A20C4	0180-0159	1	CAPACITOR-FXD 220UF+-20% 10VDC TA	56289	150D227X0010S2
A20C5	0160-2055	1	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A20CR1	1901-0376	2	DIODE-GEN PRP 35V 50NA DO-7	28480	1901-0376
A20CR2	1901-0376		DIODE-GEN PRP 35V 50NA DO-7	28480	1901-0376
A20R1	0757-0442	3	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A20R2	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A20R3	0698-3160	2	RESISTOR 31.6K 1% .125W F TC=0+-100	16299	C4-1/8-T0-3162-F
A20R4	0757-0280	3	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A20R5	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A20R6	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A20R7	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A20R8	0757-0438	1	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A20R9	0698-3160		RESISTOR 31.6K 1% .125W F TC=0+-100	16299	C4-1/8-T0-3162-F
A20U1	1820-1199	1	IC SN74LS 04 N INV	01295	SN74LS04N
A20U2	1820-1197	1	IC SN74LS 00 N GATE	01295	SN74LS00N
A20U3	1820-1270	1	IC SN74L 121 N MV	01295	SN74L121N
A20U4	1820-1144	2	IC SN74LS 02 N GATE	01295	SN74LS02N
A20U5	1820-0621	1	IC SN74 38 N BUFFER	01295	SN7438N
A20U6	1820-1144		IC SN74LS 02 N GATE	01295	SN74LS02N
A20U7	1820-1247	1	IC SN74L 123 N MV	01295	SN74L123N
A20U8	1820-1212	1	IC SN74LS112 N FLIP-FLOP	01295	SN74LS112N
A21	03968-60949	1	HP-IB TALK CONTROL, PCA	28480	03968-60949
A21C1	0160-0174	2	CAPACITOR-FXD .47UF +80-20% 25WVDC CER	56289	5C11B7-CML
A21C2	0160-0157	1	CAPACITOR-FXD 4700PF +-10% 200WVDC POLYE	56289	292P47292
A21C3	0160-0174		CAPACITOR-FXD .47UF +80-20% 25WVDC CER	56289	5C11B7-CML
A21R1	0757-0280	2	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A21R2	0757-0442	1	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A21R3	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A21U1	1820-1212	3	IC SN74LS112 N FLIP-FLOP	01295	SN74LS112N
A21U2	1820-1212		IC SN74LS112 N FLIP-FLOP	01295	SN74LS112N
A21U3	1820-1199	1	IC SN74LS 04 N INV	01295	SN74LS04N
A21U4	1820-1206	1	IC SN74LS 27 N GATE	01295	SN74LS27N
A21U5	1820-1144	2	IC SN74LS 02 N GATE	01295	SN74LS02N
A21U6	1820-1144		IC SN74LS 02 N GATE	01295	SN74LS02N
A21U7	1820-1212		IC SN74LS112 N FLIP-FLOP	01295	SN74LS112N
A21U8	1820-1270	1	IC SN74L 121 N MV	01295	SN74L121N
A21U9	1820-1202	1	IC SN74LS 10 N GATE	01295	SN74LS10N
A21U10	1820-1197	2	IC SN74LS 00 N GATE	01295	SN74LS00N
A21U11	1820-0621	1	IC SN74 38 N BUFFER	01295	SN7438N
A21U12	1820-1197		IC SN74LS 00 N GATE	01295	SN74LS00N

Table 7-16. HP-IB Assemblies A19—A22, Parts List (Option 007) (Continued)

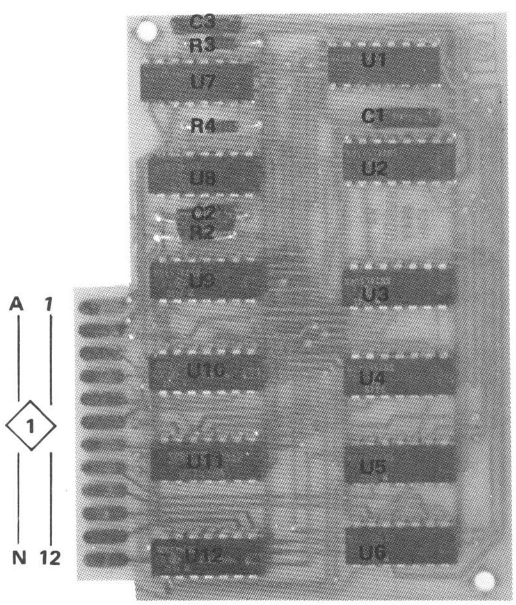
Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A22	03968-60950	1	HP-IB INTERCONNECT, PCA	28480	03968-60950
A22C1	0180-0229	1	CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X901082
A22R1	1810-0136	2	NETWORK-RES 10-PIN-SIP .1-PIN-SPCG	28480	1810-0136
A22R2	1810-0136		NETWORK-RES 10-PIN-SIP .1-PIN-SPCG	28480	1810-0136
A22R3	0757-0280	1	RESISTOR 1K 1% .125W F TC=0±100	28480	0757-0280
A22S1	T-03013	1	MULTIPLE SWITCH	28480	T-03013
A22U1	1820-1053	2	IC SN74 14 N SCHMITT	01295	SN7414N
A22U2	1820-1207	1	IC SN74LS 30 N GATE	01295	SN74LS30N
A22U3	1820-1053		IC SN74 14 N SCHMITT	01295	SN7414N
			A22 MISCELLANEOUS		
	1251-1115	3	PLZG KEY-PRINTED CIRCUIT CONN	71785	456-07-35-003
	1251-2035	1	CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-300
	1251-4040	1	CONNECTOR, 24-PIN	71785	57-20240-8
	03968-20106	2	SPACER, HP-IB CONNECTOR	28480	03968-20106
	1251-1626	2	CONNECTOR-PU EDGE 12 CONT/ROW 2-ROWS	28480	1251-1626
	03968-60945		HP-IB ASSEMBLY (INCLUDES FOLLOWING ITEMS)	28480	03968-60945
A19	03968-60947	1	INTERFACE, P.C.A.	28480	03968-60947
A20	03968-60948	1	LISTEN CONTROL, P.C.A	28480	03968-60948
A21	03968-60949	1	TALK CONTROL P.C.A.	28480	03968-60949
A22	03968-60950	1	INTERCONNECT, P.C.A.	28480	03968-60950
C1	0160-0174	2	CAPACITOR-FXD .47UF +80-20% 25WVDC CER	28480	0160-0174
C2	0160-0174		CAPACITOR-FXD .47UF +80-20% 25WVDC CER	28480	0160-0174
U1	1826-0324	1	IC LM209K V RGLTR	27014	LM209K
	0340-0150	2	INSULATOR-BSHG-FLG .117-ID	86928	A364-19
	0380-0644	2	STANDOFF, METRIC	00000	OBD
	1200-0043	1	INSULATOR-XSTR TO-3 .02-THK	76530	322047
	1205-0021	1	HEAT-DISSIPATOR SGL TO-3 PKG	99978	UP-TO-3
	2190-0074		2	28480	2190-0074
	2190-0105	4	WASHER-LK HLCL NO.-6 .141-IN-ID	28480	2190-0105
	2190-0108	4	WASHER-LK HLCL NO.-4 .115-IN-ID	28480	2190-0108
	2190-0315	2	WASHER-FL MTLC NO.-5 .13-IN-ID .25-IN-OD	28480	2190-0315
	2200-0139	4	SCREW-MACH 4-40 .25-IN-LG PAN-HD-POZI	28480	2200-0139
	2200-0147	4	SCREW-MACH 4-40 .5-IN-LG PAN-HD-POZI	28480	2200-0147
	2260-0001	1	NUT-HEX-DBL-CHAM 4-40-THD .094-THK	28480	2260-0001
	2260-0009	1	NUT-HEX-W/LKWR 4-40-THD .094-THK .25-A/F	28480	2260-0009
	2360-0193	4	SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI	28480	2360-0193
	3050-0066	2	WASHER-FL MTLC NO.-6 .147-IN-ID	28480	3050-0066
	03968-00950	1	BRACKET, HP-IB	28480	03968-00950
	03968-00951	1	HEAT SINK, HP-IB	28480	03968-00951
	03968-00952	1	PLATE, HP-IB	28480	03968-00952





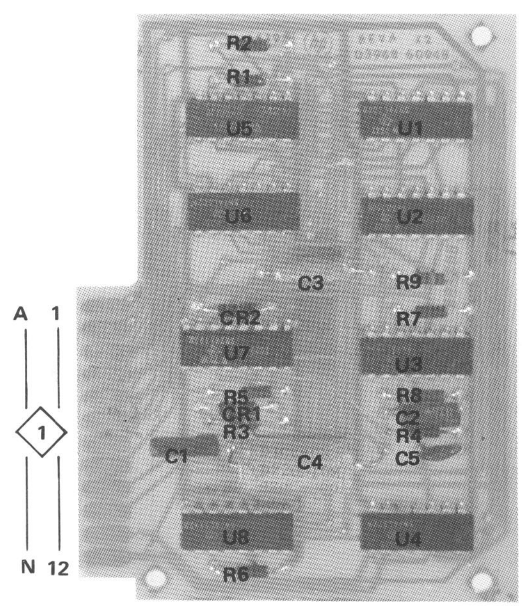
NOTE:

1 PINS 1 THROUGH 15 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH S ARE ON THE REVERSE SIDE.



NOTE:

1 PINS 1 THROUGH 15 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH S ARE ON THE REVERSE SIDE.



NOTE:

1 PINS 1 THROUGH 12 ARE ON THE COMPONENT SIDE OF THE CIRCUIT BOARD. PINS A THROUGH N ARE ON THE REVERSE SIDE.

Figure 7-45. HP-IB Interface PCA's A19—A22 (Option 007), Parts Location

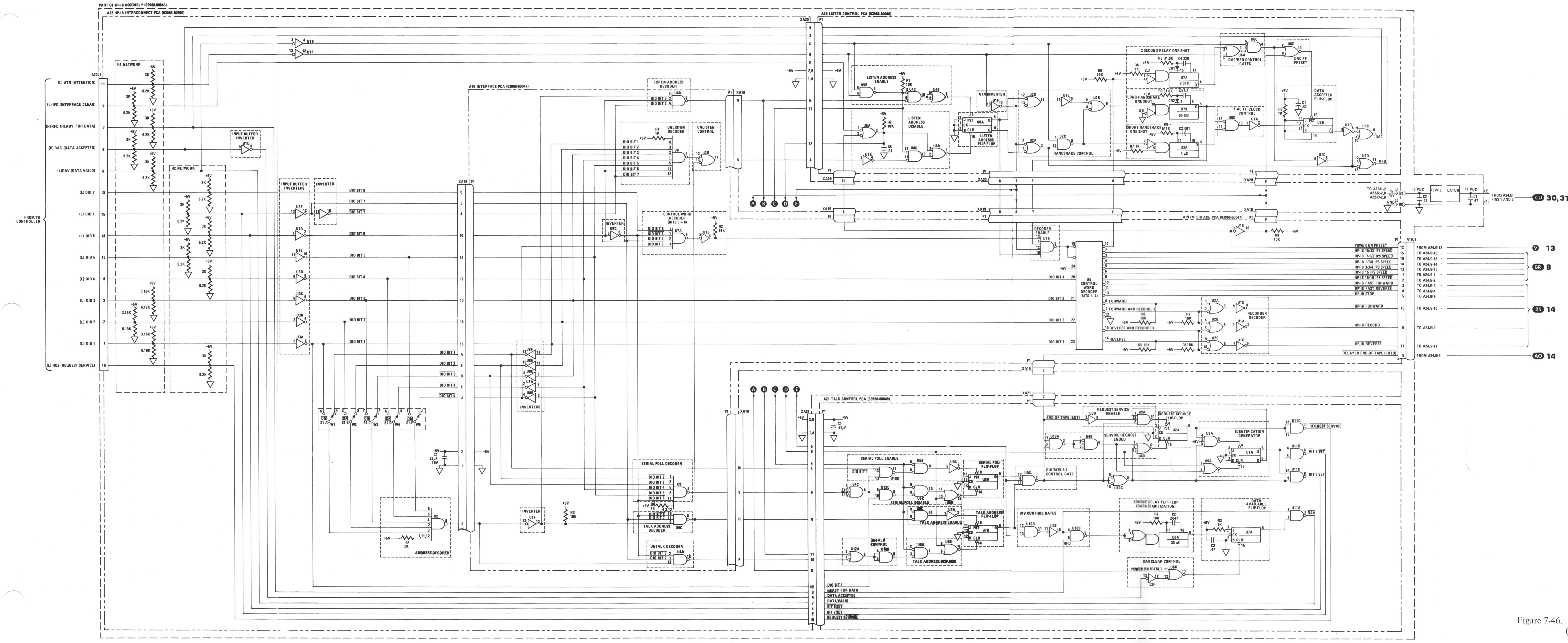


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Figure 7-46. HP-IB Interface PCA's A19–A22 (Option 007), Schematic Diagram

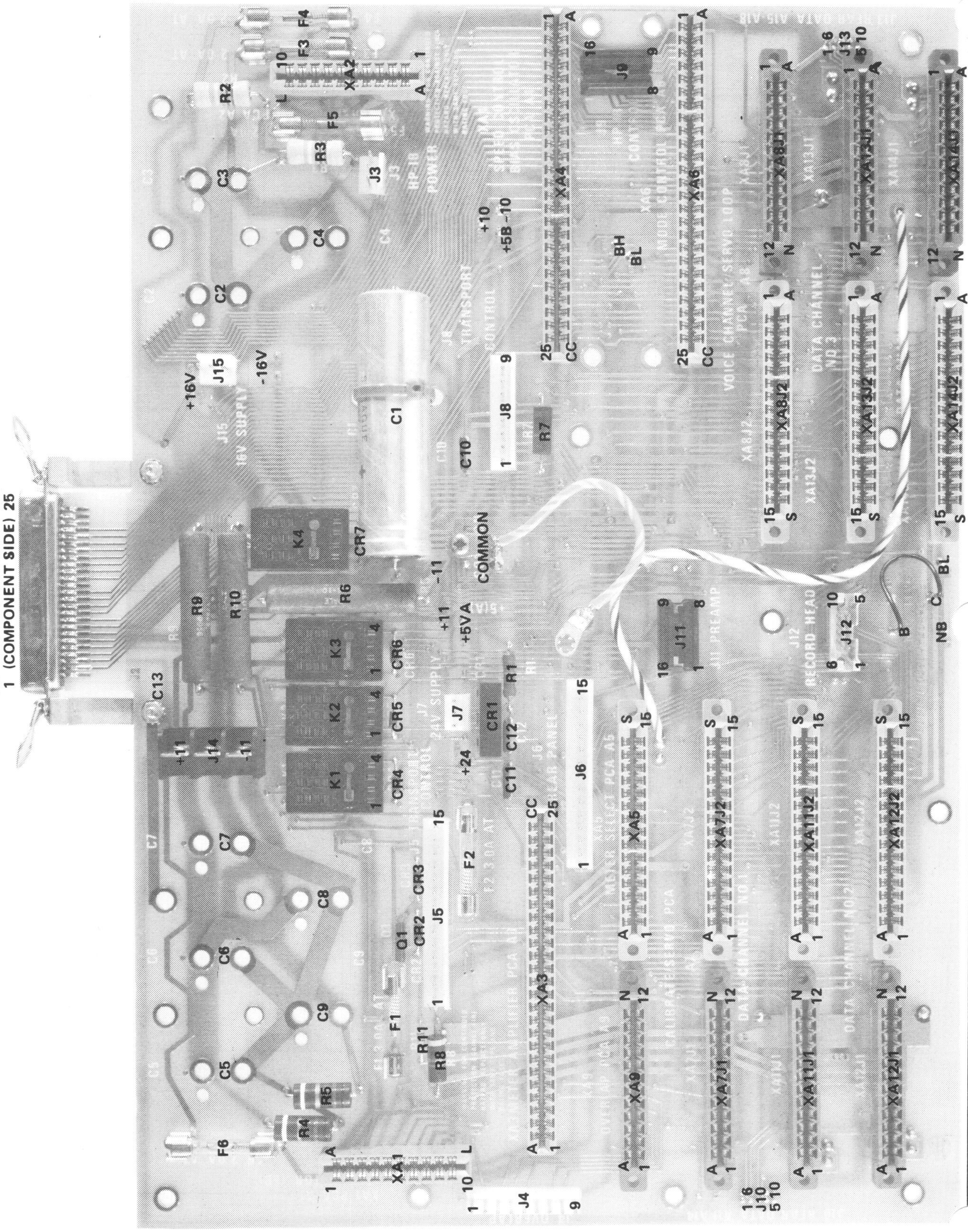

Figure 7-47. 3964A Interconnect PCA A24 Connector Identification

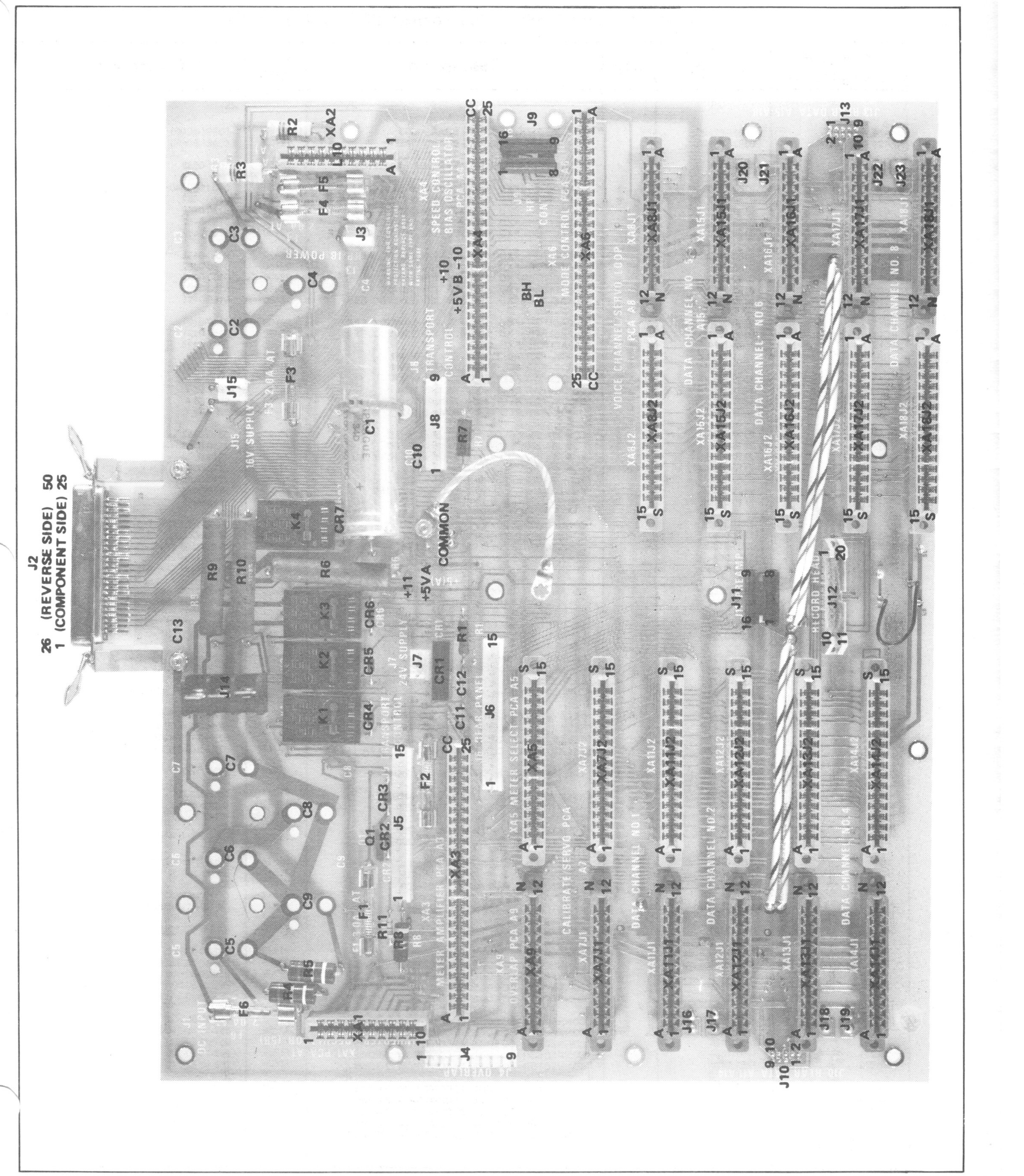

Figure 7-48. 3968A Interconnect PCA A24 Connector Identification

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Figure 7-49. Model 3964A/3968A Interconnect PCA A24, Wiring Diagram

Table 7-17. 3964A/3968A Interconnect PCA A24, Parts List

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A24	03964-60490	1	PCA, INTERCONNECTING BOARD (3964A)	28480	03964-60490
A24	03968-60490	1	PCA, INTERCONNECTING BOARD (3968A)	28480	03968-60490
BR1	1901-0638	1	DIODE–MULT FULL WAVE BRIDGE RECTIFIER	28480	1901-0638
C1	0180-0685	1	CAPACITOR–FXD 1100UF +75 -10% 40 VDC AL	56289	34D118G040HS0
C2	0180-0452	8	CAPACITOR–FXD .013F +75 -10% 25 VDC AL	28480	0180-0452
C3	0180-0452		CAPACITOR–FXD .013F +75 -10% 25 VDC AL	28480	0180-0452
C4	0180-0452		CAPACITOR–FXD .013F +75 -10% 25 VDC AL	28480	0180-0452
C5	0180-0452		CAPACITOR–FXD .013F +75 -10% 25 VDC AL	28480	0180-0452
C6	0180-0452		CAPACITOR–FXD .013F +75 -10% 25 VDC AL	28480	0180-0452
C7	0180-0452		CAPACITOR–FXD .013F +75 -10% 25 VDC AL	28480	0180-0452
C8	0180-0452		CAPACITOR–FXD .013F +75 -10% 25 VDC AL	28480	0180-0452
C9	0180-0452		CAPACITOR–FXD .013F +75 -10% 25 VDC AL	28480	0180-0452
C10	0150-0121	3	CAPACITOR–FXD .1UF +80 -20% 50 WVDC CER	28480	0150-0121
C11	0150-0121		CAPACITOR–FXD .1UF +80 -20% 50 WVDC CER	28480	0150-0121
C12	0150-0121		CAPACITOR–FXD .1UF +80 -20% 50 WVDC CER	28480	0150-0121
C13	0160-0174	1	CAPACITOR–FXD .47UF	28480	0160-0174
CR2	1901-0159	6	DIODE–PWR RECT 400V 750MA DO-41	04713	SR1358-4
CR3	1901-0159		DIODE–PWR RECT 400V 750MA DO-41	04713	SR1358-4
CR4	1901-0159		DIODE–PWR RECT 400V 750MA DO-41	04713	SR1358-4
CR5	1901-0159		DIODE–PWR RECT 400V 750MA DO-41	04713	SR1358-4
CR6	1901-0159		DIODE–PWR RECT 400V 750MA DO-41	04713	SR1358-4
CR7	1901-0159		DIODE–PWR RECT 400V 750MA DO-41	04713	SR1358-4
F1	2110-0367		FUSE 3A 250V SLOW-BLOW 1.25 x .25 IEC	28480	2110-0367
F2	2110-0367	3	FUSE 3A 250V SLOW-BLOW 1.25 x .25 IEC	28480	2110-0367
F3	2110-0303	6	FUSE 2A 250V SLOW-BLOW 1.25 x .25 IEC	28480	2110-0303
F4	2110-0303		FUSE 2A 250V SLOW-BLOW 1.25 x .25 IEC	28480	2110-0303
F5	2110-0303		FUSE 2A 250V SLOW-BLOW 1.25 x .25 IEC	28480	2110-0303
F6	2110-0015		FUSE 2.5A 250V SLOW-BLOW 1.25 x .25 IEC	28480	2110-0015
	2110-0269	6	FUSEHOLDER, CLIP-TYPE	28480	2110-0269
J1	1251-3192	3	CONNECTOR 3-PIN M POST TYPE	27264	09-60-1031 (2403-03A)
J2	1251-0087	1	CONNECTOR 50-PIN F MICRO RIBBON	9D949	57-40500-375
J3	1251-3192		CONNECTOR 3-PIN M POST TYPE	27264	09-60-1031 (2403-03A)
J4	1251-3981	2	CONNECTOR 9-PIN M POST TYPE	27264	09-60-1091
J5	1251-3198	2	CONNECTOR 15-PIN M POST TYPE	27264	09-60-1151 (2403-15A)
J6	1251-3198		CONNECTOR 15-PIN M POST TYPE	27264	09-60-1151 (2403-15A)
J7	1251-3192		CONNECTOR 3-PIN M POST TYPE	27264	09-60-1031 (2403-03A)
J8	1251-3981		CONNECTOR 9-PIN M POST TYPE	27264	09-60-1091
J9	1200-0767	2	SOCKET–IC 16-CONT DIP-SLDR-TERMS	91506	316-AG5D-3R
J11	1200-0767		SOCKET–IC 16-CONT DIP-SLDR-TERMS	91506	316-AG5D-3R
J12 (3964A)	1251-4424	1	CONNECTOR 10-PIN	28480	1251-4424
J12 (3968A)	1251-3905	1	CONNECTOR 20-PIN M RECTANGULAR	76381	3428-2003
J14	0360-0678	1	BARRIER BLOCK 3-TERM POLYP 1.19-IN-L	28480	0360-0678
J15	1251-3192	1	CONNECTOR 3-PIN M POST	27264	09-60-1031 (2403-03A)
K1	0490-0347	4	RELAY 24 VDC CONT 5A 115 VAC FORM 4A	78277	62R4-24DC-SCO
K2	0490-0347		RELAY 24 VDC CONT 5A 115 VAC FORM 4A	78277	62R4-24DC-SCO
K3	0490-0347		RELAY 24 VDC CONT 5A 115 VAC FORM 4A	78277	62R4-24DC-SCO
K4	0490-0347		RELAY 24 VDC CONT 5A 115 VAC FORM 4A	78277	62R4-24DC-SCO
Q1	1854-0433	1	TRANSISTOR NPN SI PD=90W FT=2MHZ	28480	1854-0433
R1	0698-3410	1	RESISTOR 3.16K 1% .5W F TC=0+-100	91637	MFF-1/2-10
R2	0698-3634	2	RESISTOR 470 5% 2W MO TC=0+-200	11502	RG42
R3	0698-3634		RESISTOR 470 5% 2W MO TC=0+-200	11502	RG42
R4	0698-3629	2	RESISTOR 270 5% 2W MO TC=0+-200	11502	RG42
R5	0698-3629		RESISTOR 270 5% 2W MO TC=0+-200	11502	RG42
R6	0818-0056	3	RESISTOR 1 3% 10W PW TC=0+-50	91637	CW10-1-11W-T2-1R0-H
R7	0811-1678	1	RESISTOR 10 5% 2W PW TC=0+-400	75042	BWH2-10R-J
R8	0812-0058	1	RESISTOR 8.2 5% 2W PW TC=0+-400	75042	BWH2-8R2-J
R9	0818-0056		RESISTOR 1 3% 10W PW TC=0+-50	91637	CW10-1-11W-T2-1R0-H
R10	0818-0056		RESISTOR 1 3% 10W PW TC-0+-50	91637	CW10-1-11W-T2-1R0-H
R11	0698-3441	1	RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-TO-215R-F
XA1	1251-2034	2	CONNECTOR–PC EDGE 10-CONT/ROW 2-ROWS	71785	252-10-30-300
XA2	1251-2034		CONNECTOR–PC EDGE 10-CONT/ROW 2-ROWS	71785	252-10-30-300
XA3	1251-2915	10	CONNECTOR–PC EDGE 25-CONT/ROW 2-ROWS	71785	252-25-30-300
XA4	1251-2915		CONNECTOR–PC EDGE 25-CONT/ROW 2-ROWS	71785	252-25-30-300
XA5	1251-1886	22	CONNECTOR–PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-340
XA6	1251-2915		CONNECTOR–PC EDGE 25-CONT/ROW 2-ROWS	71785	252-25-30-300
XA7J1	1251-1886		CONNECTOR–PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-340
XA7J2	1251-2915		CONNECTOR–PC EDGE 25-CONT/ROW 2-ROWS	71785	252-25-30-300
XA8J1	1251-1886		CONNECTOR–PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-340
XA8J2	1251-1626	4	CONNECTOR–PC EDGE 12-CONT/ROW 2-ROWS	71785	252-12-30-340
XA9	1251-1626		CONNECTOR–PC EDGE 12-CONT/ROW 2-ROWS	71785	252-12-30-340
XA11J1	1251-1886		CONNECTOR–PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-340
XA11J2	1251-2915		CONNECTOR–PC EDGE 25-CONT/ROW 2-ROWS	71785	252-25-30-300
XA12J1	1251-1886		CONNECTOR–PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-340
XA12J2	1251-2915		CONNECTOR–PC EDGE 25-CONT/ROW 2-ROWS	71785	252-25-30-300

Table 7-17. 3964A/3968A Interconnect PCA A24, Parts List (Continued)

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
XA13J1	1251-1886		CONNECTOR—PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-340
XA13J2	1251-2915		CONNECTOR—PC EDGE 25-CONT/ROW 2-ROWS	71785	252-25-30-300
XA14J1	1251-1886		CONNECTOR—PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-340
XA14J2	1251-2915		CONNECTOR—PC EDGE 25-CONT/ROW 2-ROWS	71785	252-25-30-300
XA15J1 (3968A)	1251-1886		CONNECTOR—PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-340
XA15J2 (3968A)	1251-2915		CONNECTOR—PC EDGE 25-CONT/ROW 2-ROWS	71785	252-25-30-300
XA16J1 (3968A)	1251-2915		CONNECTOR—PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-340
XA16J2 (3968A)	1251-2915		CONNECTOR—PC EDGE 25-CONT/ROW 2-ROWS	71785	252-25-30-300
XA17J1 (3968A)	1251-1886		CONNECTOR—PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-340
XA17J2 (3968A)	1251-1626		CONNECTOR—PC EDGE 12-CONT/ROW 2-ROWS	71785	252-12-30-340
XA18J1 (3968A)	1251-1886		CONNECTOR—PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-340
XA18J2 (3968A)	1251-1626		CONNECTOR—PC EDGE 12-CONT/ROW 2-ROWS	71785	252-12-30-340
XK1	0490-0468	4	SOCKET—RLY 16-CONT CRADLE-PKG	02288	3005-4
XK2	0490-0468		SOCKET—RLY 16-CONT CRADLE-PKG	02288	3005-4
XK3	0490-0468		SOCKET—RLY 16-CONT CRADLE-PKG	02288	3005-4
XK4	0490-0468		SOCKET—RLY 16-CONT CRADLE-PKG	02288	3005-4
			MISCELLANEOUS		
	0360-0365	4	TERMINAL—LUG—SLDR 6 SCR .143/.093 ID	78189	2104-06-00
	0360-1514	10	TERMINAL—STUD SGL—PIN PRESS—MTG	28480	0360-1514
	0520-0130	2	SCREW—MACH 2-56 .375-IN-LG PAN-HD-POZI	28480	0520-0130
	0590-0381	1	NUT—HEX—W/LKWR 6-32-THD .12-THK .25-A/F	78189	511-061800-01
	1251-1115	10	POLARIZING KEY—PC EDGE CONN	28480	1251-1115
	1251-4509	16	CONNECTOR—SGL CONT SKT .062-IN-BSC-SZ	28480	1251-4509
	2190-0112	2	WASHER—LK HLCL NO.-2 .088-IN-ID	28480	2190-0112
	2260-0009	2	NUT-HEX-W/LKWR 4-40-THD .094-THK .25-A/F	28480	2260-0011
	2360-0197	1	SCREW—MACH 6-32 .375-IN-LG PAN-HD-POZI	28480	2360-0197
	8120-2122		CABLE—UNSHLD 22AWG 2-CNDCT UL-1061	28480	8120-2122
	8150-0303		WIRE 24AWG BK 1000V PVC 7X32 105C	28480	8150-0303
	8150-1634	4	WIRE 14AWG W/BR/GY 1000V PVC 19X27 105C	28480	8150-1634
	8150-2462	4	WIRE 14AWG BK 600V PVC 41X30 105C	28480	8150-2462
	8150-3284		WIRE 18AWG G/Y 600V PVC 19X30 105C	28480	8150-3284
	03968-20041	2	MOUNTING BLOCK, MOTHER	28480	03968-20041
	03968-20290	2	HEADER	28480	03968-20290
	1251-1115	14	PLZG KEY—PRINTED CIRCUIT CONN	71785	456-07-35-003
	1251-4212	2	CONNECTOR, MULTI-CONNECT	28480	1251-4212
	2110-0269	6	FUSEHOLDER—CLIP TYPE .25 FUSE	91506	6008-32CN
	2190-0034	16	WASHER—LK HLCL NO.-10 .194-IN-ID	28480	2190-0034
	2680-0021	3	SCREW—MACH 10-32 5-IN-LG RD-HD-SLT STL	28480	2680-0021
	2680-0099	16	SCREW—MACH 10-32 .375-IN-LG PAN-HD-POZI	28480	2680-0099
	2740-0003	3	NUT—HEX—W/LKWR 10-32-THD .125-THK	73734	9227
	3050-0003	2	WASHER—FL NM NO.-6 .141-IN-ID .375-IN-OD	73734	1471
	03968-00450	1	CLAMP, CAPACITOR	28480	03968-00450
	03968-00451	1	CLAMP, CAPACITOR	28480	03968-00451
	03964-60054	1	WIRE, JUMPER	28480	03964-60054
	03968-60054	1	WIRE, JUMPER	28480	03968-60054

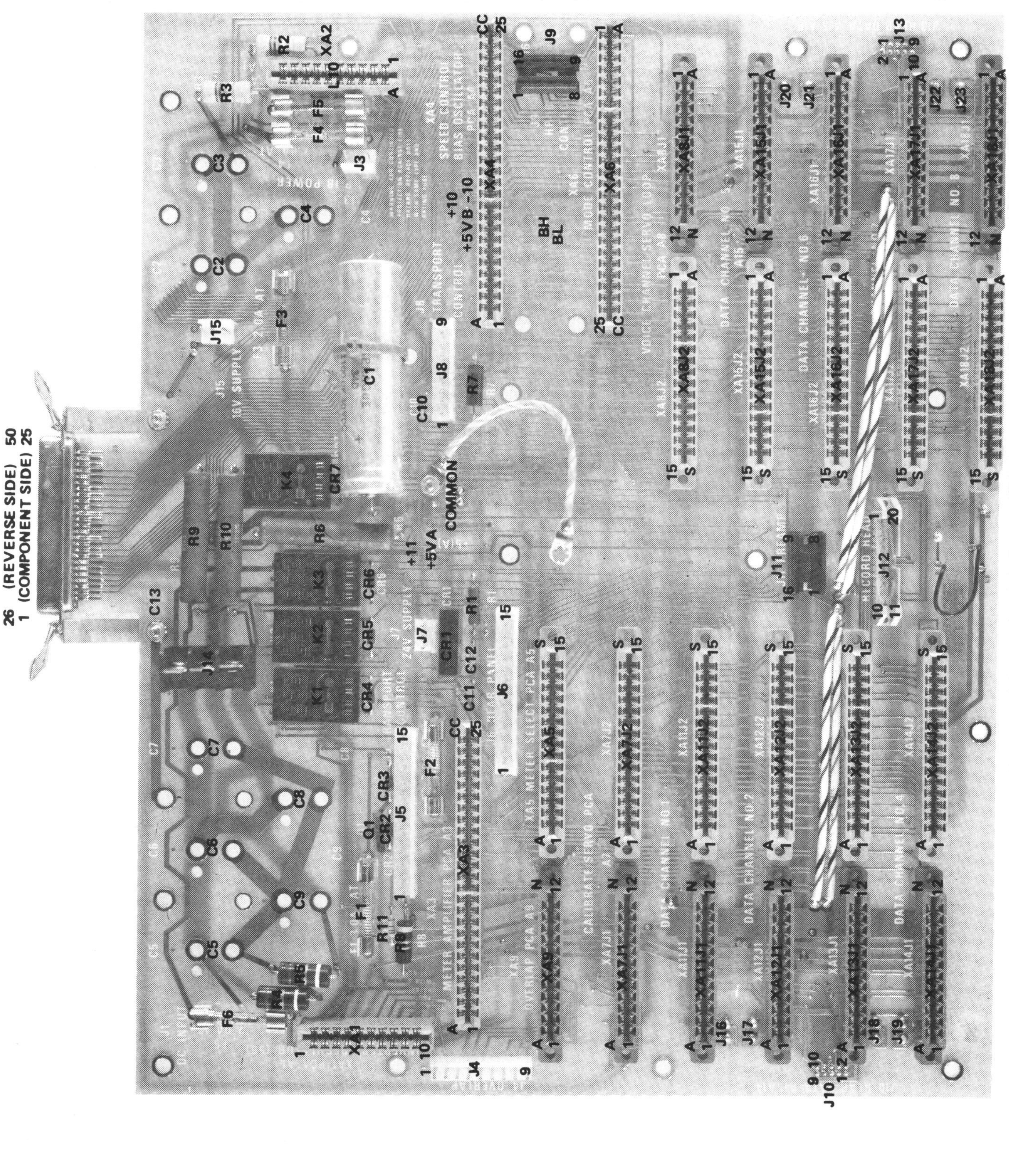

Figure 7-50. Interconnect PCA A24, Parts Location

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SERVICE SHEET

Figure 7-51. Model 3964A/3968A Power Input Circuit and Chassis, Wiring Diagram

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